AERONAUTICAL ENGINEERING REVIEW

APRIL 1950

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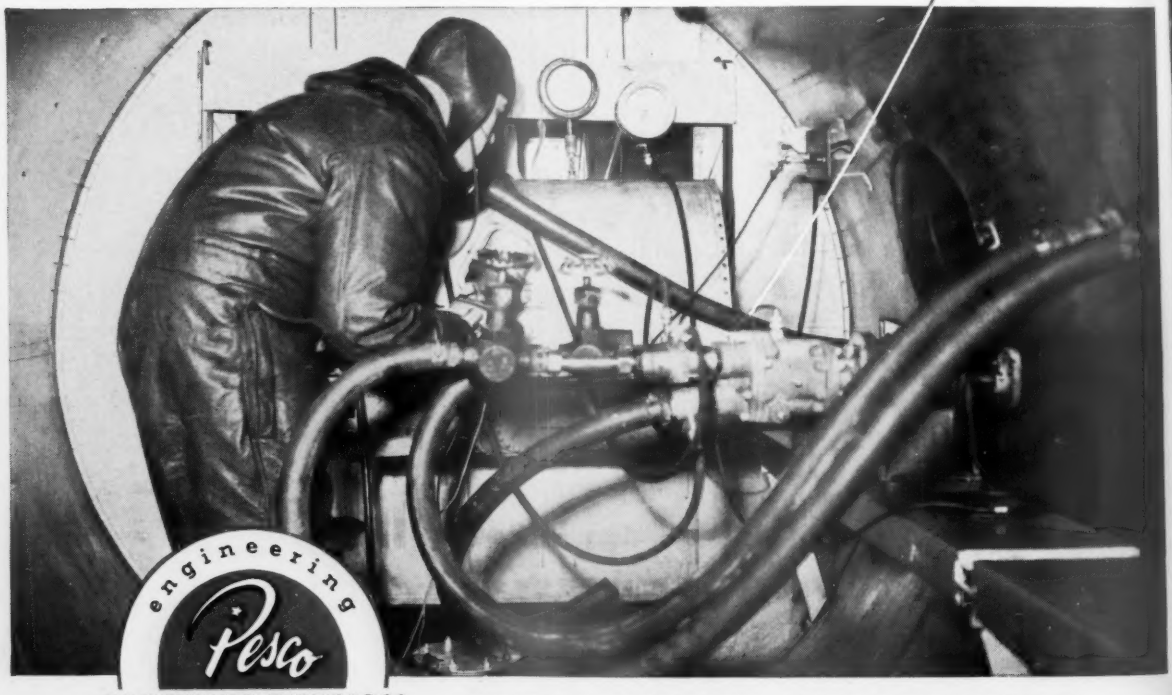

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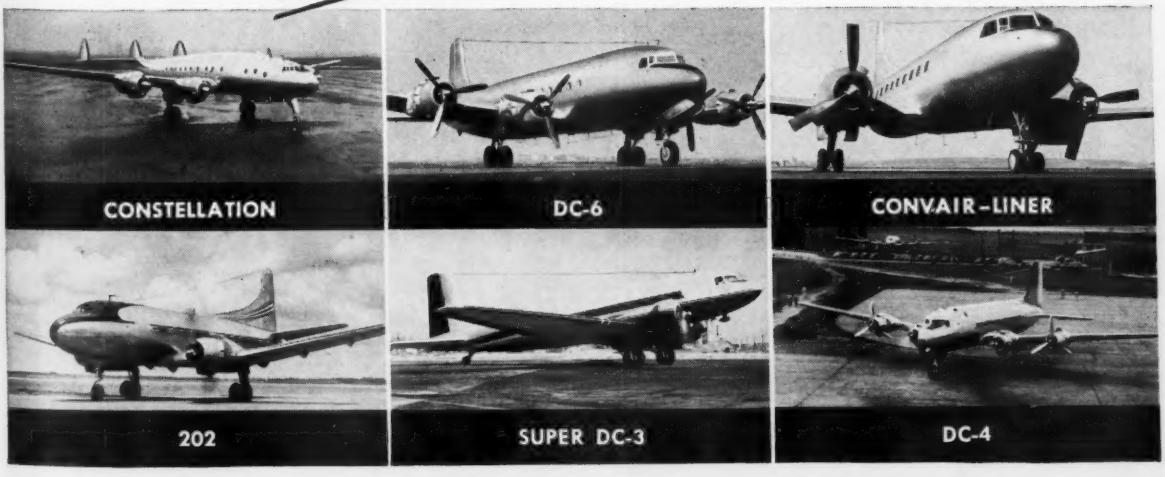

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Cover—North American YF-93A (*right*) and YF-86D (*left*) jet fighters. In background is North American B-45 jet bomber.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 9 **APRIL, 1950** **No. 4**

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Published Monthly by the Institute of the Aeronautical Sciences, Inc.

Ideas For Sale

Joe Thompson, Charlie Byrum, and Charlie Young produce one of G-E's greatest "stocks-in-trade"—ideas. One of many problem-solving squads whose successes read like an aviation roll call of progress—electrically-driven autopilots, a high-frequency ignition system, airborne radar, all-electric remote fire control systems—they have new ideas and approaches that may be what you're looking for in your business.

Working closely together, and with other specialists from G-E's pool of knowledge, they have sparked many advances over the last decade. Experts at analysis, they form a hard-driving team which utilizes their widely-varied backgrounds. The vigor of their youth is backed up by G-E's generations of experience.

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I.A.S. News

A Record of People and Events of Interest to Institute Members

Personal Aircraft Meeting in Wichita to Stress Low-Speed Flight Problems

Two-Day Meeting Set for May 19–20 in Hotel Lassen; William B. Stout and Col. Hammond McD. Monroe to Be Guest Speakers; Events Will Include Inspection of Local Aircraft Plants

Guest of Honor: *William B. Stout, principal speaker at May 20 Dinner, will analyze current status of private flying.*

THE I.A.S. SEVENTH ANNUAL PERSONAL AIRCRAFT MEETING will be held on Friday and Saturday, May 19 and 20, in the Hotel Lassen, Wichita, Kan. The general theme of the meeting this year will be low-speed flight and low-speed control of personal aircraft. Plans formulated thus far call for spokesmen for the N.A.C.A. and the manufacturers to present their approaches to the task of achieving better control and maneuverability at low speeds without sacrifice of good cruising characteristics. Other topics to be discussed will include personal aircraft designed for specific purposes.

The meeting will open on Friday morning with a tour of the local aircraft manufacturing plants for out-of-town visitors, and the Technical Sessions will be held on Saturday, May 20. The selection of Saturday for the Technical Sessions proved ideal in last year's meeting, since it enabled a large group of local engineers to attend without loss of time from their positions.

The Program Committee includes: Marvin J. Gordon, Aerodynamics Engineer, Beech Aircraft Corporation, Chairman of the I.A.S. Wichita Section; D. C. Heimburger, Engineering Test Pilot, Boeing Airplane Company, Vice-Chairman; H. Delmar Chitwood, Flight Test Engineer, Boeing Airplane Company, Secretary; and Robert W. Burnham, Engineer, Boeing Airplane Company, Treasurer. Other committee members are: Prof. Kenneth Razak, University of Wichita; Tom Salter, Vice-President and Chief Engineer, Cessna Aircraft Company; Melvin H. Snyder, Head, Aeronautical Engineering Department, University of Wichita; Peter Altman, Vice-President, Continental Motors Corporation; Ray Hermes, Contracts Manager, Aeronca Aircraft Corporation; W. C. Jamouneau, Chief Engineer, Piper Aircraft Corporation; Franklin T. Kurt, Sales Engineer, Grumman Aircraft Engineering Corporation; and Fred E. Weick, Director, Personal Aircraft Research Center, A. & M. College of Texas.

▸ **Field Trip**—The inspection of manufacturing activities is being arranged for out-of-town visitors by the local Section officers. The plants of Beech Aircraft Corporation, Boeing Airplane Company, and Cessna Aircraft Company will be visited.

▸ **Dinner**—Following the field trip, a Dinner will be held in the Hotel Lassen on Friday evening. Guest of honor and principal speaker will be William B. Stout, F.I.A.S., Stout Research Laboratories, Phoenix, Ariz. Tickets will be available at $3.50 per plate.

(*Continued on page 7*)

Host: *Marvin J. Gordon, Aerodynamics Engineer, Beech Aircraft Corporation, and Wichita Section Chairman, heads Committee planning details of meeting.*

New Joint Activity

American Helicopter Society Moves Its Office to 2 East 64th Street. I.A.S. Assumes Management Under 2-Year Agreement

BY JOINT AGREEMENT between the Councils of the two societies, the Institute and the American Helicopter Society have combined their management functions for a trial period of 2 years. Beginning April 1, 1950, the A.H.S. offices will be located in the Institute's headquarters building at 2 East 64th Street, New York. This action was announced by the American Helicopter Society at the annual Rotary Wing Forum held in Philadelphia on March 30–31.

In order that all I.A.S. members will be familiar with the relationship, the following pertinent excerpts have been taken from the formal agreement:

Joint Privileges

For a period of 2 years from the date of the approval of the joint agreement, the I.A.S. undertakes to house and manage the business affairs of the A.H.S. The members of either society will have no voting or other privileges in the other society except as follows:

(a) Members of either society may attend national or local meetings of the other society without payment of registration fees.

(b) Members of the A.H.S. will have access to I.A.S. libraries (East and West) on the same basis as I.A.S. members.

(c) Members of the A.H.S. may use the I.A.S. buildings (East and West) on the same basis as I.A.S. members.

Policy Committee

Each Society will appoint three (3) members to serve jointly as a policy committee to discuss matters of common interest to both societies. In addition, the I.A.S. President (or Executive Committee Chairman) will serve as Chairman of the Joint Policy Committee.

Responsibilities of A.H.S.

During the life of this agreement, the A.H.S. will:

(a) Retain its name and identity.

(b) Operate under its own Constitution and By-Laws.

(c) Elect its own officers.

(d) Organize and conduct its own meetings—with limited assistance from I.A.S. staff.

(e) Compile and edit its own publications (I.A.S. assistance will be limited to production and distribution of forum proceedings and news letter only).

(f) Its responsible officers will maintain constant liaison with the Secretarial Assistant located in the headquarters office at 2 East 64th Street, New York.

Responsibilities of I.A.S.

During the life of this agreement, the I.A.S. will provide:

(a) Part-time services of a Secretarial Assistant who will be located in the headquarters office.

(b) General administrative services, including necessary office space, telephone, mail services, etc.

(c) The necessary membership services, including mailing of bills, collection of dues, maintenance of membership records, mailing of meeting notices, annual ballots for officers, etc.

(d) Limited assistance (as requested) in A.H.S. Meetings.

(e) Production of the *Proceedings* of the A.H.S. Annual Rotary Wing Forum and semiannual news letter. It is understood that the I.A.S. will assume no responsibility or liability for statements made in A.H.S. meetings or publications.

Accounting Procedures

In consideration of the above arrangements, A.H.S. will agree to turn over to the I.A.S.:

(a) A complete account of A.H.S. assets and liabilities at the time of the signing of this agreement, such account to be certified by a responsible A.H.S. officer. It is to be understood that the I.A.S. will not undertake any responsibility for any liabilities of the A.H.S. incurred prior to date of this agreement and/or for any expenditures not specifically authorized by the I.A.S. subsequent to the agreement.

(b) All cash and other assets as of the date of the agreement.

(c) All dues from A.H.S. members during the lifetime of this agreement. A.H.S. dues shall not be raised or lowered without the approval of a Joint Policy Committee.

Dr. Alexander Klemin, President of the American Helicopter Society, whose efforts were primarily responsible for the conclusion of this agreement between the two societies.

(d) All income from the sale of A.H.S. publications.

(e) All other income.

The I.A.S. will set up separate books for the A.H.S. operations. It will furnish periodic reports of condition to the officers of the A.H.S. Responsible officers of the A.H.S. may have access to the books at any time.

The financial responsibility of the I.A.S. for any claims that may be made against the A.H.S. for any reason by a third party will be limited to the net assets of the A.H.S.

Termination of Agreement

This agreement may be terminated on sixty (60) days' notice by order of the council of either society. If so terminated, the liabilities of the I.A.S. shall be limited to:

(a) Turning back to the officers of the A.H.S. all members records, correspondence files, surplus publications, etc.

(b) Turning back whatever assets remain to the credit of the A.H.S. after applying the charges (agreed upon by the councils of the two societies).

General

The above agreement is entered into with the intent and understanding that the I.A.S. will perform every reasonable service to foster the interests and activities of the A.H.S. It is understood also that the A.H.S. will do nothing to prejudice the best interest of the I.A.S.

Dr. Alexander Klemin

As this issue went to press, we learned of the untimely death of Dr. Alexander Klemin, a Founder Member, Benefactor, and Fellow of the Institute. He passed away suddenly on March 14 at his home in Greenwich, Conn. A complete obituary of Dr. Klemin will be published in the May issue of the REVIEW.

(*Continued from page 5*)

▸ **Technical Sessions**—Two Technical Sessions will be held in the Hotel Lassen on Saturday. The morning session will be devoted entirely to the problems of low-speed flight and low-speed control. Three papers will be presented. Three papers are also being scheduled for the afternoon session.

▸ **Luncheon**—Col. Hammond McD. Monroe, U.S.A., will be guest speaker at Saturday's luncheon in the Hotel Lassen. He will speak on the important role of light aircraft in the operation of the U.S. Army. Colonel Monroe is Head of the Air Division of the Research and Development Section of the U.S. Army Ground Forces. Luncheon tickets have been priced at $1.75.

The Program Committee, with the Wichita Section officers as a nucleus, is bringing to completion final arrangements for this meeting. A final program and luncheon and dinner reservations will be mailed to all I.A.S. Members later this month.

Honored by N.Y.U.: (*Left to right*) *Dean Thorndike Saville of the College of Engineering, N. Y. U.; the late Dr. Alexander Klemin; Comdr. Harry F. Guggenheim; Dr. Hugh L. Dryden; Hon. Robert Moses, Commissioner of Parks, City of New York; and Chancellor Harry Woodburn Chase, N. Y. U.*

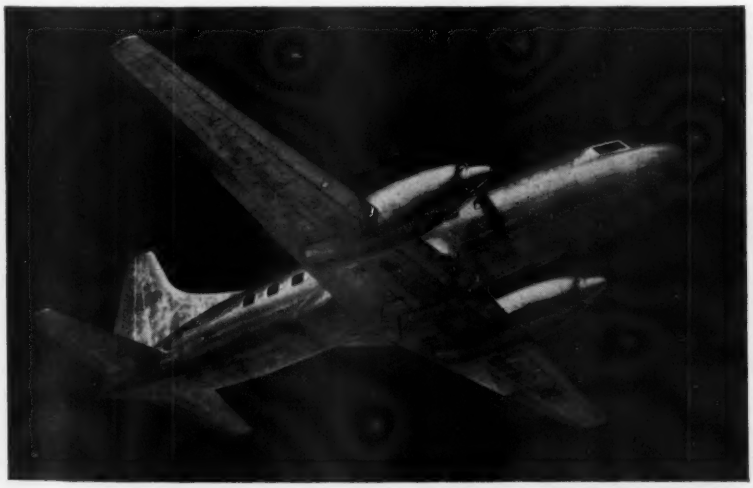
Allison Purchases Convair-Liner for Turboprop Installation

Allison Division of General Motors Corporation has purchased a Convair-Liner, fitted for cargo, for immediate installation of two 2,750-hp. Allison T38 turboprop engines. The plane will be equipped with propellers made by G.M.C.'s Aeroproducts Division at Dayton, Ohio. First flight is expected in June.

Only minor modifications to the production-type nacelles are required, and this modification and preliminary flight test will be accomplished at the Consolidated Vultee Aircraft Corporation plant in San Diego. The airplane will then be brought to Indianapolis for extensive flight tests by Allison to accumulate operating data on the reliability and dependability of turbine-powered transport aircraft. Later, it will be used as a demonstrator for other aircraft manufacturers, the military services, and commercial air-line operators. It also may be loaned to air lines for regular on-line cargo runs to accumulate further experience and data, which will be shared with the rest of the aircraft manufacturing and air-line industries.

The choice of the Convair-Liner for the new transport, already dubbed the Convair-Turboliner, was based on the relatively low cost of the required modifications and because Convair-Liners have been operated more extensively on air lines throughout the world than any other postwar twin-engined transport.

The propellers to be supplied by the Aeroproducts Division will be similar to models developed under the sponsorship of Navy BuAer. The Navy propellers have been tested previously in conjunction with a T38 turboprop engine installed in the nose of a B-17 as a fifth engine for the aircraft.



Convair-Liner in Role of First U.S. Turboprop Transport: *Retouched photograph shows how Convair-Liner will appear with two 2,750-hp. Allison T38 turboprop engines. Allison Division will take delivery from Consolidated Vultee after its preliminary flight test in June and put it through an extensive test program. Aeroproducts propellers, developed for U.S. Navy, will be used.*

N.Y.U. Confers Honorary Degrees at Guggenheim School Anniversary

In ceremonies marking the twenty-fifth anniversary of the founding of the Daniel Guggenheim School of Aeronautics of the New York University College of Engineering, honorary degrees of Doctor of Engineering were presented on January 26 to four men who have been closely associated with the development of aeronautics throughout their careers.

Honorary degrees were awarded to:

• **Hugh L. Dryden,** H.F.I.A.S., Director, National Advisory Committee for Aeronautics, "for his outstanding achievements in experimental aerodynamics, for his wartime accomplishments in the development of guided missiles, for his editorial guidance on many technical journals in the field of aeronautical science, for his zealous efforts in maintaining our international leadership in aeronautical research."

• **Harry F. Guggenheim,** H.M.I.A.S., who helped create the pioneer School of Aeronautics, "aviator, engineer, author, philanthropist, and informed patron of the aeronautical sciences; statesman; ambassador plenipotentiary; and citizen extraordinary."

• **Alexander Klemin,** F.I.A.S., Director of the School for its first 15 years, in recognition of his exceptional service to the Guggenheim School of Aeronautics and to aeronautical engineering as "one of the greatest pioneers in aeronautical education in this country." (Dr. Klemin died on March 14, 1950.)

• **Robert Moses,** developer of airports and airport approaches at LaGuardia and Idlewild, "engineer of engineers, courageous planner, coordinator and administrator of great public enterprises, developer of the terrestrial facilities necessary for aviation, exemplar of the century old definition of engineer as one directing the great forces in nature to the use and convenience of man."

The four were presented for the degrees by Dean Thorndike Saville, of the College of Engineering, and were invested by Chancellor Harry Woodburn Chase. The ceremonies took place in Stevenson House on the Hall of Fame Campus.

Midwestern Conference on Fluid Dynamics

A Midwestern Conference on Fluid Dynamics, together with a meeting of the American Physics Society, Fluid Dynamics Division, is announced by the Department of Mechanical Engineering of the University of Illinois. This conference is to be held on Friday and Saturday, May 12 and 13, 1950, concurrently with the dedication of a new Mechanical Engineering Building at the University.

The Institute of the Aeronautical Sciences is one of the sponsoring societies, and its members are cordially invited to attend.

Sessions on the following subjects are being planned: Aerodynamics—External Flow; Mechanical Engineering—Internal Flow; Symposium on Hypersonic and Low-Density Flow Techniques; Turbulence and Aero-Physics; Astro-Physics, Computing Machines, Multiple Theory of Fluid Dynamics, and Meteorology; Chemical Engineering; and Hydrodynamics and Continuation of External and Internal Flow.

Reservations for accommodations and for the various banquets must be made before May 1. Reservation forms may be obtained from Prof. J. R. Carroll, Jr., Mechanical Engineering Building, University of Illinois, Urbana, Ill.

Canadian-Built Twin-Jet Fighter Makes First Flight

The first long-range all-weather fighter of its type, the Avro CF-100 made its first flight from Malton Airport near Toronto on January 19. The CF-100 was designed and built by A. V. Roe Canada Limited to specifications set up by the Royal Canadian Air Force. It is the first front-line fighter to be entirely designed, engineered, and built in Canada. Work on the present prototype was begun in 1946 from plans formed the previous year. W. A. (Bill) Waterton, test pilot, who has been loaned to Avro Canada by Gloster Aircraft to assist in the flight-test program, reported that the aircraft handled extremely well during its 20 min. in the air.

The Avro CF-100 is 52½ ft. long, with a wing span of 52 ft., and its height from the top of its cabin to the ground is 10 ft. 7 in. It is fitted with tricycle landing gear. A crew of two is carried: pilot and radio-navigator. Equipment includes the latest navigational and operational devices to exploit its long-range and all-weather characteristics.

The first flight was made with two Rolls-Royce Avon turbojet engines mounted close to the aircraft's fuselage. It is intended at a later date to use Orenda turbojet engines designed and built by Avro Canada (see picture, page 12).

The new aircraft will complement the North American F-86A single-engined jet fighter, which is being built for the R.C.A.F. by Canadair Limited of Montreal. The two aircraft will have separate tasks. Whereas the F-86 is intended to perform as a single-seater day fighter, with corresponding characteristics of high speed and rate of climb, the Avro CF-100 has been produced primarily for interception at long distances from base and in adverse weather conditions.

National Meetings Calendar

May 19–20	Personal Meeting,	Aircraft Wichita
July 12–14	Annual Meeting,	Summer Los Angeles

(For details see page 101)

T.W.A. Joins I.A.S. as Corporate Member

Transcontinental and Western Air, Inc., the country's oldest transcontinental passenger air line, has recently become a Corporate Member of the Institute. In adding its name to the list of I.A.S. Corporate Members, T.W.A. joins the scores of other organizations whose activities and products have contributed to the progress of American aviation. T.W.A. itself has been in operation continuously for 20 years and has been a pioneer in many phases of aviation. President of T.W.A. is Ralph S. Damon, I.A.S. Fellow.

T.W.A. flies 30,000 miles of domestic and international routes between San Francisco and Bombay and serves 55 cities in the United States and 16 points in Europe, North Africa, the Near East, and India. In its employ are 11,500 persons, including more than 550 pilots. Main offices are located at 630 Fifth Ave., New York 20, N.Y.

On February 5, the company marked the beginning of its 5th year of international operations. At peak seasons, it schedules more than 50 weekly transatlantic passenger flights, and it operates a weekly all-cargo flight supplying over-the-weekend delivery at cities between New York and Cairo. This summer, to accommodate Holy Year traffic to Rome, T.W.A. will schedule more than 60 transatlantic flights per week.

T.W.A., the largest user of Constellation aircraft, is putting 26 additional Constellations into operation during the coming year, 20 of them for transatlantic service. These new aircraft will bring the total number of Constellations in the fleet to 61 and will give T.W.A. the world's largest fleet of four-engined postwar airplanes. The interiors of all its Constellations are also being standardized, and the seating capacity is being increased.

Twenty of the new Constellations were purchased last year in anticipation of a high volume of tourist and religious travel to Europe in 1950. Stimulus for the increased traffic is the Holy Year celebration in Rome, which is boosting all European travel and attracting an unprecedented number of air pilgrims to Rome and to the shrines of Lourdes in France and Fatima in Portugal.

T.W.A.'s northern route across Europe enters through Shannon and Paris and serves Zurich, Geneva, and Milan. At Rome, it converges with the southern route through Madrid, Lisbon, and The Azores. Beyond Rome, the air line serves Athens and Cairo, Tunis, Algiers, Basra, Saudi Arabia, and Bombay.

W. A. M. Burden Continues Library Gifts

The generous gifts of sections of his outstanding aeronautical library to I.A.S. by W. A. M. Burden in past years are well known. He has added this year more than 1,000 aeronautical

books, periodicals, and reports, valued at more than $6,000, including 350 books on the technical, historical, business, and military aspects of aviation; over 600 books and periodicals on aeronautics published in China and Japan; and 200 issues of current periodicals. The collection includes more than 40 albums of photographs and clippings on such subjects as transoceanic air service; stratosphere flight; the Schneider Trophy races; autogiros; rockets; and, particularly, on World War I and early American airplanes, engines, flights, and pilots. A substantial part of this was collected by Ernest Jones when he was publishing his magazine *Aeronautics*, from 1907 to 1915. A number of reports of Congressional hearings on aviation subjects and about 40 pamphlets on meteorology are included in the collection.

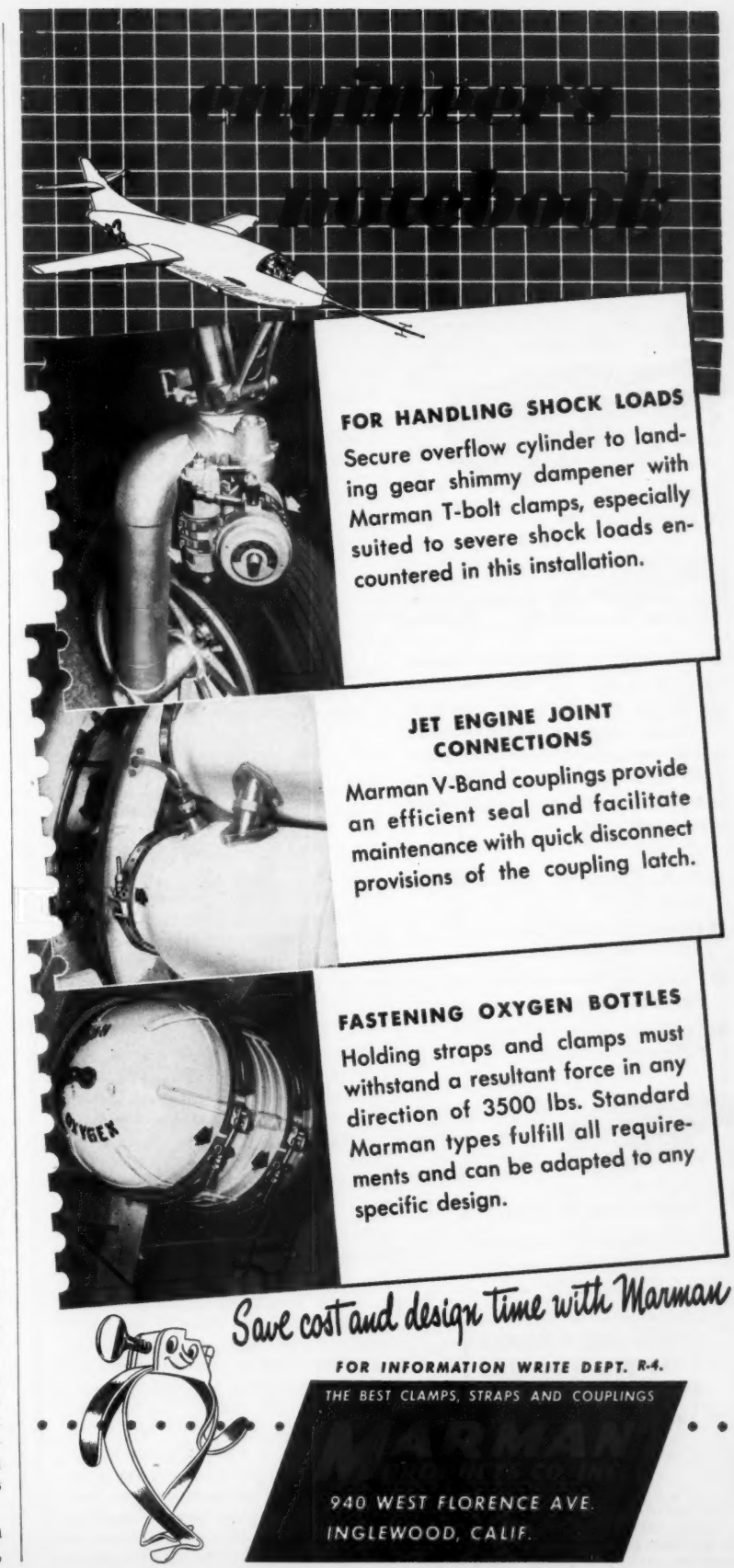
Gifts to the Institute Collections

Colonel E. E. Aldrin added 320 reports and magazines and 300 books to his previous generous gifts. John P. V. Heinmuller gave an album of Transoceanic and Pioneer air-mail covers, three albums of Philippine Islands flown air-mail covers, and a French airship lithograph in color of about 1900, adding to his previous gifts.

Mrs. Mary R. B. McAdie sent a copy of the recent book, *Alexander McAdie, Scientist and Writer*, through the courtesy of Col. Stedman Shumway Hanks. The Eclipse-Pioneer Division of Bendix Aviation Corporation sent *N.A.C.A. Technical Notes* and *Technical Memorandums*, through the courtesy of Miss Mildred M. Baker. Over 300 technical magazines were received from the Curtiss-Wright Corporation, Propeller Division, through the courtesy of Mrs. Miriam Hoffman. Reports were received from the Cornell Aeronautical Laboratory, Inc., through the courtesy of Miss Elma T. Evans.

Forty reports covering operational development and flight research work on air-borne radar were received from American Airlines, Inc., through the courtesy of William Littlewood and R. W. Ayer. Over 60 technical and historical books on air navigation, air-line operation, and other aspects of aviation were received from John P. McLaughlin of American Overseas Airlines, Inc. About 50 technical periodicals were received from Robert J. Schoonmaker, of Baltimore. Technical reports were sent by the British Joint Services Mission, adding to its previous generous gifts.

Additional gifts were received from Aeronautical Research Institute,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I.A.S. Newslines

▸**Burnham Adams,** A.F.I.A.S., has joined AiResearch Manufacturing Company as Sales Manager, following 3½ years as Vice-President of Lear, Inc., in charge of the LearCal Division.

▸Heads Honeywell Aero Engineering . . . **Col. Frank R. Cook,** U.S.A.F., A.F.I.A.S., has joined Minneapolis-Honeywell Regulator Company as Director of Aero Engineering, where he will guide department of more than 300 in work on high-speed aircraft and guided missiles. Colonel Cook, formerly Chief, Research Division, U.S.A.F., Washington, D.C., retired from Air Force after 17 years' service.

▸**Carl T. Doman,** A.F.I.A.S., is now staff Assistant to L. D. Crusoe, Vice-President and General Manager of Ford Division, Ford Motor Company, Dearborn, Mich. Mr. Doman's previous position was Vice-President and Chief Engineer, Aircooled Motors, Inc., Syracuse, N.Y.

▸Honored by Radio Engineers . . . **Dr. George L. Haller,** A.F.I.A.S., Dean of the School of Chemistry and Physics at The Pennsylvania State College, has been made a Fellow of the Institute of Radio Engineers. The I.R.E. cited "his work on aircraft antennas" and "his diversified radio effort during the war." Dr. Haller has been associated with Air Force radio and electronics since 1935 and during the war worked on the air-borne magnetic detector, radar countermeasures, and radio and radar control of guided missiles with outstanding success. In addition to his College duties, he is

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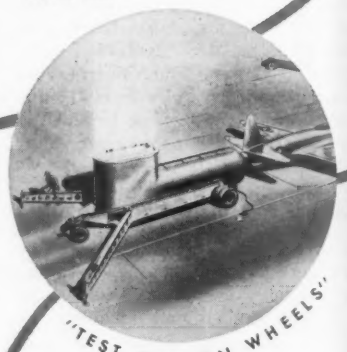

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▸**William G. Street,** A.F.I.A.S., formerly with the Engineering Division of The Glenn L. Martin Company, has been appointed to the Senior Staff of the Operations Research Office of The Johns Hopkins University at Ft. Lesley J. McNair, Washington, D.C.

Corporate Member News

• Turbo Propeller . . . **Aeroproducts Division** of General Motors Corporation has announced its participation in the modification of a Convair 240 commercial transport airplane to be powered by two Allison T-38 turboprop engines. Aeroproducts is providing propellers similar to models developed for Navy BuAer. The Navy propellers were tested in conjunction with a T-38 turboprop installed in the nose of a B-17 as a fifth engine. An Aeroproducts propeller was used on the first flight of a turboprop-powered aircraft when a Consolidated XP-81 was flown in December, 1945, under U.S.A.F. sponsorship.

• Right-Angle Gear Unit . . . **Airborne Accessories Corporation** has redesigned their ANGLgear right-angle gear unit for universal mounting. The universal mounting feature reduces the models required from four to two. New unit includes a rectangular, four-hole, mounting flange with an internal pilot on both ends of the housing. These mounting arrangements are in addition to the three-hold side mounting originally employed. In addition to the standard 1–1 ratio, a 2–1 ratio is now an optional extra.

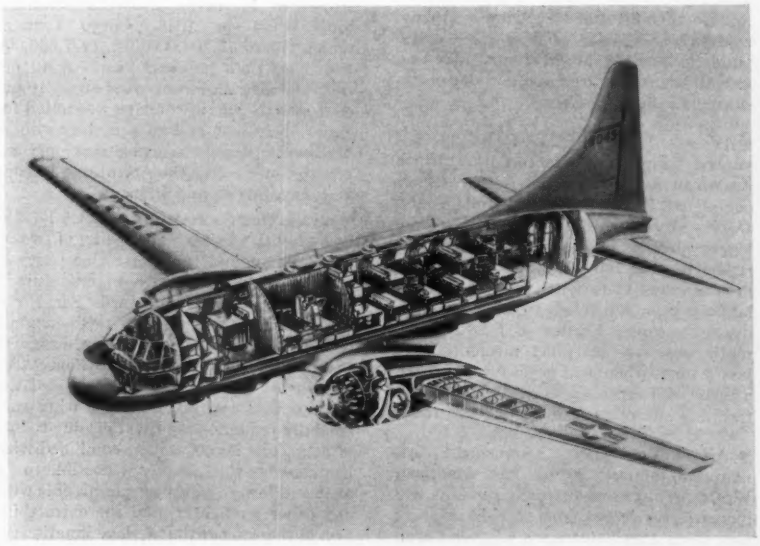
• "Fail-Safe" Control . . . Utilizing printed-circuit techniques, **AiResearch Manufacturing Company** has produced a miniature electronic regulator, incorporating the first "Fail-Safe" circuit devised for remote positioning control. It is also useful for automatic temperature and pressure regulation to microscopic degrees. Weighing less than 2 lbs., it is a variation of AiResearch's "Weather Brain" modified for more general use. Applications include automatic trim-tab adjustment, multiengined throttle control, carburetor and cabin air-temperature control, anti-icing control, and cabin-pressure release control. In case of electric system failure, the electronic control will instantly "hold" until manual control can take over.

• Orders DC-6B's . . . **American Airlines, Inc.,** has ordered eleven new 52-passenger DC-6B's from Douglas Aircraft Company, Inc., with deliveries to begin in February, 1951. Value of the order, which includes spare parts, is $13,000,000. The new transports, powered by four P. & W. R-2800-CB16 engines, will have 1,200 more horsepower than present DC-6's and will cruise at speeds well over 300 m.p.h. Seating capacity will be the same as in the previous model, despite an increase of 61 in. in length. The space gained by this additional length will be used for cargo. Pay load will be increased by 4,500 lbs. American Airlines, Inc., American Overseas Airlines, Inc., and Air France have entered into agreements that provide for an interchange of passengers and air cargo by the French air line, which serves six continents, and each of the other lines. Pact will provide one-ticket travel or one airway bill to almost any part of the world. The first of two high-density transports was put into service between Frankfurt and Berlin on February 1 by American Overseas. The aircraft, a Douglas DC-4 revamped to seat 64 passengers, has largest passenger capacity of any scheduled air liner operating within Europe. Traffic on American Airlines, Inc., during 1949 was substantially greater than for any other year in the company's history. Figures and percentage increase of 1949 over 1948 are: 1,569,460,673 passenger-miles, 16 per cent; 3,263,760 passengers carried, 15.9 per cent; load factor, 64.6, against previous year's 60.4; 9,057,965 mail ton-miles, 10.3 per cent; 5,581,082 express ton-miles, 0.9 per cent; 32,981,422 freight ton-miles, 42.1 per cent; and operating factor, 98.2, against previous year's 96.6.

• Better Bonanza . . . **Beech Aircraft Corporation** began deliveries of new Model B35 version of Beechcraft Bonanza toward end of January. Refinements listed by Beech include: increase in take-off horsepower rating from 185 hp. at 2,300 r.p.m. to 196 hp. at 2,450 r.p.m., reduction by almost half the time required to retract and extend tricycle landing gear, increased and faster flap travel, and reduction in take-off and landing distances (over 50-ft. obstacle at sea level, no wind) of 18 and 26 per cent, respectively. A quarterly dividend of $0.20 per share was voted on January 24, payable on February 20 to stockholders of record at close of business on February 6. This dividend makes total of $0.45 paid on 599,865 issued and outstanding shares of common stock during first 6 months of present fiscal year. Backlog of business on January 24 was approximately $11,000,000, with total sales for October–December, first fiscal quarterly period, at $3,088,747.

• New Superfort . . . **Boeing Airplane Company** is working on a new model of the Superfortress, the Boeing RB-50B, which is to be equipped as a modern and efficient aerial photographic and weather reconnaissance laboratory for the U.S.A.F. New model is to be equally useful as a normal strategic bomber. New cameras, improved radar, aerial refueling, and weather recording instruments are being installed at Wichita. One of the main problems involved in taking photographs at high altitudes from the RB-50B was to keep the optical system of the seven camera ports free of condensation, fog, and ice. Boeing engineers designed a nozzle to fit the length of each port at the edge of the glass. Resembling an airfoil section, the nozzle has slot measuring 0.05 in. Preheated cabin air is forced through this slot across the inside of the glass in a continuous parallel layer, keeping it free of condensation. Airflow is shut off when camera is fired, preventing any disturbance across face of camera port.

• A.F. Reserve Training . . . Students at **Cal-Aero Technical Institute** desiring to participate in the Air Force Reserve pro-



FLYING CLASSROOM FOR NAVIGATORS

U.S.A.F. has ordered 48 T-29 navigation trainers manufactured by Consolidated Vultee Aircraft Corporation. Design of the T-29 is based on the 40-passenger Convair-Liner commercial transport. Curtains divide cabin into four compartments. First training compartment, just forward of wing, is radio operator's station. Aft of this is the radar training section, divided into two compartments by a longitudinal curtain. Main cabin aft of radar section includes standard navigation training equipment and stations for ten students. Four astrodomes are visible on top of fuselage. Large cylinders in tail section are oxygen bottles for system supplying 18-man crew for 6 hours at 20,000 ft.

gram will soon have available to them courses paralleling those for A. & E. Mechanic's license, plus basic military training. Objective of the Reserve group is to be able to take over efficiently the responsibilities of an Air Depot in time of national emergency.

• Continentals in Italy . . . Two Italian aircraft now in production, the Macchi B308 high-wing two-place monoplane and the B320 low-wing four-passenger monoplane, feature engines manufactured by **Continental Motors Corporation.** B308 mounts an A65, or, optionally, C85 or C90. B320 is powered by two E185's mounted in wing nacelles.

• 300-Hp. Coupling . . . **Eclipse-Pioneer Division,** Bendix Aviation Corporation, has announced development of small flexible drive coupling, to handle torque loads up to 300 hp. at 9,000 r.p.m. with misalignment up to 3.5°. Heart of new coupling, which makes possible the use of remotely mounted engine-driven gear box for accessory power take-offs, is series of eight steel diaphragms, each having a hyperbolic wall section whose thickness tapers to less than ten thousandths of an inch.

• Fifteen-Oz. V.H.F. . . . Six V.H.F. frequencies at an output of 2 watts are provided by new remote-controlled transmitter designed for personal aircraft. Manufactured by **Lear, Inc.,** under designation of Model RT-10CR, transmitter weighs just 15 oz. Companion Cockpit Selector Unit weighs 10 oz.

• New Home . . . St. Louis branch of **Minneapolis-Honeywell Regulator Company** and its Brown Instruments Division have moved into new office building at 4354 Olive St., St. Louis. New structure, first to be built and owned by company, contains 6,600 sq.ft. of floor space. Expanding business in St. Louis area and growth in automatic control activity necessitated the larger quarters.

• Passes Tests . . . U.S.A.F. T-28 advanced trainer, manufactured by **North American Aviation, Inc.,** has successfully completed Phase One flight and ground tests. More than 65 hours of flying were logged in series of 75 flights. Stability is reported to be 100 per cent in high-speed ground, runs even with tires of tricycle landing gear subjected to blowout with dynamite caps. Feature of T-28 is automatic nose-steering relief mechanism to break turns when gear is set for too sharp a turn. Edwards Air Force Base, Muroc, Calif., is site of present Phase Two tests.

• Air Cargo Pact . . . Agreement announced January 26 by **Pan American World Airways** and Flying Tiger Line will increase service available to U.S. shippers now using Pan American's Clipper Cargo for international shipping. Shipments on one airwaybill will be made from any of the 43 cities to which the Flying Tiger Line is certified by C.A.B. to any point on six continents served by Pan American. Cargo picked up by Flying Tiger Line will connect with Pan American at New York and Boston for Europe and Africa and for the Far East at Los Angeles, San Francisco, Portland, and Seattle; 37,299,083 revenue ton-miles were flown by Pan American in 1949, 3,458,425 ton-miles more than in 1948. Cargo tonnage amounted to 47,704,000 lbs., or 7,666,000 lbs. more than previous year. A 10 per cent overall gain in ton-miles and a 19 per cent overall gain in tonnage was noted for cargo operations in Pan American's three divisions. Biggest increase was on company's route across the Atlantic to Europe and on to Africa and India.

Avro's New Turbojet: *Sir Roy Dobson (center), President of Avro Canada, inspects new Orenda turbojet engine, which will be installed in Avro CF-100 twin-jet fighter. Walter N. Deisher, General Manager of the company, is on the left, and Leslie Foster is on the right.*

• Phase One Successful . . . U.S.A.F. XF-91 high-altitude interceptor, first of two on order, has completed Phase One series of 40 flights conducted by manufacturer's pilots and crews at Edwards Air Force Base, Muroc, Calif. Flight-test personnel of **Republic Aviation Corporation,** designers and builders, describe results as "spectacular beyond general expectations." Tests showed that the inverse-taper wing successfully reduces wing-tip stalls due to loss of lift. The inverse taper, combined with leading-edge slots, makes it possible to fly at speeds lower than those permissible with any other jet fighter, and the extra thinness of the wing at the fuselage junction reduces drag and permits a more even flow of air at this point. The variable incidence of the wing permits a high angle of attack for take-offs and landings and a low angle of attack for high-speed flight. Aileron-booster system and tandem-wheel landing gear of the XF-91 also operated satisfactorily. Phase Two tests will be conducted by the Air Force to learn specific performance capabilities with present power plant (G-E 5,200-lb. thrust J-47 turbojet) and afterburning. Four rocket motors are to be installed later to boost rate of climb and give additional power for combat.

• In Miniature . . . **Servomechanisms, Inc.,** has released details of its "Mini-Chopper," which weighs 1.3 oz. and has less than one-eighth the volume of previous d.c.-a.c. choppers. Designed for modulation, demodulation, rectification, and inversion of intelligence signals, it will operate at temperatures from 55° to 120°C. and has a life expectancy of over 1,000 hours. It mounts in a seven-prong miniature socket and will modulate to frequencies from 60 to 600 cycles at rated input of 6.3 volts.

• Largest Peacetime Order . . . **Sperry Gyroscope Company** has received a contract from the U.S. Army Ordnance Department for quantity production of a new and highly complex antiaircraft gunfire control system. Termed the largest peacetime order in the company's history, new contract is seen as possible contributor to continued increase in rate of employment during the coming year.

• Highest Honor . . . On February 5 in Rome, Italy, Italian Foreign Minister Count Carlo Sforza presented the Order of the Star of Italian Solidarity to Warren Lee Pierson, Chairman of the Board of **Trans World Airline.** The award, the highest honor that Italy can bestow on someone who is not an Italian citizen, was given in recognition of T.W.A.'s efforts toward reconstruction of Italy from an aviation standpoint and for uniting Italy and the United States by air transportation. A 10 per cent increase in passenger operations for 1949 over 1948 has been reported by T.W.A. 1,226,861,000 revenue passenger-miles were flown in 1949, an increase of 10.2 per cent; 1,516,352 persons traveled by T.W.A., an increase of 14.2 per cent; and passenger load factor increased from 57.9 to 60.7 on the domestic routes and from 57.1 to 61.8 on international routes. Cargo was busier, too, with increases of 3.8 per cent in mail ton-miles, 20.4 per cent in domestic air freight, and 32.7 per cent in international air cargo. The Sky Coach operation, including transcontinental Sky Coach flights begun on December 27, 1949, accounted for 49,679,000 passenger-miles. As T.W.A. entered its 5th year of scheduled transatlantic and international flight operations on February 5 of this year, statistics showed that in the 4-year period it had made 6,670 scheduled ocean crossings, flown 284,000 passengers on international routes for a total of 885,000,000 passenger-miles, and carried 36,600,000 ton-miles of international mail and cargo.

• Stratocruiser Service . . . **United Air Lines, Inc.,** put three Boeing Stratocruisers into service on January 15 to operate over the California-Hawaii route. Seven round-trip flights weekly between San Francisco and Honolulu are being made, including daylight and overnight trips. Time is $9^1/_2$ hours to Hawaii and $8^3/_4$ hours return. Newly designed heat funnel in use at Chicago shops warms up engines for

winter operation in less than half the time formerly required. Only 20 min. are required to heat engine to 50° when temperature is 5° above zero. The funnel is about 40 in. long. The mouth, padded with felt, fits snuggly against cowl openings of the airplane. Padded slots, 120° apart, enclose the base of propeller shafts. A 3-ft. flexible hose connects the funnel to heater and blower equipment in United's standard "comfortizer" trucks. The heater delivers about 275 B.t.u.'s per min.

• Demonstration Magnetic Amplifier . . . **Vickers Electric Division** of Vickers Incorporated has designed demonstration unit of magnetic amplifier for educational purposes in schools and industry. Aside from showing basic principles of operation, new unit may be used to operate control circuits, such small voltage regulators for small a.c. and d.c. generators, speed control for small d.c. motors, controlled rectifier power supplies, and closed-loop positioning systems for servomechanism work.

I.A.S. Sections

Baltimore Section

W. W. Bender, *Secretary*

Dr. Harold Schutz, Staff Consultant on Microwave Electronics, The Glenn L. Martin Company, lectured on "Air-Borne Radar Development" before the Baltimore Section on December 14, 1949. The meeting was held at Maryland Hall, The Johns Hopkins University.

▸ **Radar Developments**—The speaker first briefly reviewed radar development since 1904, when it was first considered in Germany. He cited the rapid strides taken by England in the development of radar techniques and the productivity of the United States in manufacturing radar equipment. After he had explained the "echo principle" on which radar is based, he discussed the design features and limitations of radar for aircraft use. Applications of diversified types of radar to such tasks as search, fire control, bombing, and navigation were covered in the talk.

▸ **Aircraft Research**—At the January 18 meeting, held at Remsen Hall, The Johns Hopkins University, members of the Section heard Col. Benjamin S. Kelsey, U.S.A.F., M.I.A.S., speak on "The Role of Research in the Development of Military Aircraft." Colonel Kelsey is on the Staff of the National War College, Washington, D.C. He pointed out that research is "a point of view" and that "analytical inquisitiveness" is the keynote. "Development," he stated, "represents the growth, maturity, and application of new ideas." Research and development of military aircraft represents a struggle for survival—the essence is in performance. The enemy must be outperformed by utilization of all our existing technical and industrial resources. Our aim must be directed toward an effective and efficient use of our resources. We must learn to do more with less, conserve where possible, and evaluate effectively existing developments, he concluded.

Buffalo Section

R. Allen Price, *Secretary*

On January 18, a joint meeting was held with the Western New York Weather Society and the Technical Societies Council of Buffalo. About 75 persons attended the session, which was held in Norton Hall at the University of Buffalo. Stanley W. Smith, Vice-Chairman of the Section, presided.

Mr. Harry Larkin, Secretary of the Western New York Weather Society, outlined the purpose of the organization and its proposed schedule of meetings. The Western New York Weather Society, which celebrated it's first anniversary at this meeting, is associated with the American Meteorological Society.

▸ **Weather**—Guest speaker was Bernard L. Wiggins, Senior Meteorologist of the U.S. Weather Bureau, Buffalo. Mr. Wiggins gave a résumé of the work of the Weather Bureau and mentioned some of the attempts at rainmaking of 50 years ago. He displayed and explained official Weather Bureau maps showing the "Big Blow" of January 14, 1950, in the Buffalo area at 6-hour intervals. Color slides of cloud formations and their effects on weather prediction were shown. Also presented were color slides of 360° of the sky made by means of hemispherical mirrors. There was an interesting exhibit of the various instruments used by the Weather Bureau. A general discussion followed the meeting.

Dayton Section

Robert W. Hoeflein, *Secretary*

A meeting was held on January 18 in the Hilton Room of the Dayton Biltmore Hotel. The presiding officer was A. F. Arcier, Chairman of the Dayton Section. Howard E. Roberts, Aero-Thermodynamics Engineer, El Segundo Plant, Douglas Aircraft Company, Inc., presented an interesting paper, "The Earth's Atmosphere," to some 40 members of the Section.

Mr. Robert's paper, the subject of which is of great importance in the fields of astronomy, meteorology, communications, aeronautics, and astronautics, was published in full in the October, 1949, issue of the AERONAUTICAL ENGINEERING REVIEW on page 18. The paper includes a new chart of the characteristics of the earth's atmosphere constructed from the latest atmospheric data.

Mr. Roberts stated in closing that it would not be too optimistic to predict rocket flights to the moon in the not too distant future, since the great wealth of information now accumulated about the earth's outer layers make flights of this nature not at all impossible.

Detroit Section

Joseph Rutkowski, *Secretary*

William T. Bean, Research Consultant, was the speaker at the January 12 meeting held in the Rackham Memorial Building. Chairman L. M. Patrick conducted the meeting; 40 persons attended.

▸ **Stress Analysis**—"New Developments in Stress Analysis" was the title of Mr. Bean's address. He presented an interesting lecture on the correlation of (1) material, (2) design, and (3) load in the development of any product. These items were considered to be completely interdependent, and the point was made that the specification and knowledge of each one of them is essential to a good product. Mr. Bean emphasized experimental techniques for stress analysis as a necessary procedure for a rational and good product, with respect to the determination of its quality. He maintained that only experimental methods, supplemented initially by theory and formulas, could give any valid indication of such unpredictable but basically important items as fatigue loads and vibration.

The concluding portion of the lecture was devoted to the discussion and demonstration of various instruments for experimental stress analysis. Mr. Bean showed how and where these instruments can and should be used.

Toronto Section

H. C. Luttman, *Secretary*

The Annual Meeting of the Section was held in the New Mechanical Building of the University of Toronto on January 19. The guest speaker

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was Prof. T. R. Loudon, Head of the Department of Aeronautical Engineering, University of Toronto; his topic was "Photoelastic Methods of Stress Analysis." Over 100 persons were present, and a discussion period followed the talk.

▶**1950 Election**—Executive Officers for 1950 were chosen as follows: Chairman, Carl V. Lindow; Vice-Chairman, F. H. Brame; Secretary, H. C. Luttman; and Treasurer, C. F. Mathews. The new Advisory Board consists of J. C. Floyd; R. D. Hiscocks; Ben Etkin; K. M. Molson; Sid Britton; Ian Hamer; George Wait, A.V.M. (Ret.); and E. H. Dowell.

I.A.S. Student Branches

Academy of Aeronautics

On January 6, election of officers for the Spring Term was held. The following members were chosen for the offices named: Chairman, Thomas P. Buckley; Vice-Chairman, Jerome Minerva; Secretary, Jane Howieson; Corresponding Secretary, James M. Clark; Treasurer, James T. Macomb; and Sergeant-at-Arms, Linwood A. Simmons.

Air Force Institute of Technology

Two lectures were presented during the winter program. Dr. Ovrebo, of the Radiation Laboratory of the Air Materiel Command, spoke on "Infrared Radiation Applied to Modern Warfare," and H. E. Roberts, of the Douglas Aircraft Company, Inc., spoke on "The Earth's Atmosphere" (see AERONAUTICAL ENGINEERING REVIEW, October, 1949, page 18).

Officers elected for 1949–1950 are: Chairman, Lt. Col. W. H. Bireley, U.S.A.F.; Vice-Chairman, Sqd. Ldr. J. N. Brough, Royal Canadian Air Force; Secretary, Major R. R. Scott, U.S.A.F.; and Treasurer, Lt. F. W. Hartwig, U.S.A.F.

Carnegie Institute of Technology

On January 10, through the I.A.S. Student Branch, 21 aeronautic students visited the N.A.C.A. installations at Cleveland. Before observing the installations, a short lecture on the organization and purpose of the N.A.C.A. was given.

The first building visited was the Engine Research Building, which is used for testing small parts of engines, blades, compressors, and complete engines. Next inspected was the Air Service Dispatch Section, which supplies air at proper conditions for the operation of test engines. Many networks of supply lines are required, some carrying refrigerated air, high- and low-pressure air, or altitude-conditioned air.

After lunch in the cafeteria, the tour continued with the inspection of the compressor and turbine divisions, where members examined large models of centrifugal compressors. N.A.C.A. personnel explained to them the design of turbine blades of various materials and the methods of casting and testing blades.

The altitude test chamber, the altitude wind tunnel, the altitude wind-tunnel air drier, the icing-research tunnel, the hangar, the machine shop, and the 8 by 6 ft. supersonic wind tunnel were next on the inspection list. The tour was concluded with a short film on other N.A.C.A. activities.

The Catholic University of America

Forty members attended the January 11 meeting, which was held in the Martin Maloney Chemistry Auditorium. James Dutton, Treasurer, was Chairman of the meeting. Edward Woll, Development Engineer, Aircraft Gas Turbine Engineering Division, General Electric Company, spoke on "Design of Aircraft Gas Turbines." Mr. Woll's talk was patterned on a paper that was delivered at an A.S.M.E. meeting in Dayton in September, 1948.

After a brief review of turbojet development, Mr. Woll discussed the future of propeller-driven versus turbojet aircraft and then recounted the advances made by the use of thrust augmentation obtained with the injection of water and the reheating of the exhaust gases. A 20-min. color film, entitled *Jet Propulsion* and a 25-min. silent film, also in color, of various airplanes powered by G-E turbojets were shown in addition to slides. At the close of the talk, the speaker conducted a half-hour question-and-answer period.

Mr. Dutton presented an engraved cigarette lighter to Mr. Woll at the conclusion of the lecture, and the meeting was adjourned to the Aeronautical Engineering Department, where refreshments were served.

Northrop Aeronautical Institute

As guests of Northwest Airlines, 30 members were conducted through the Boeing Stratocruiser at Los Angeles International Airport on January 13. Northwest Airlines officials conducted the group through all parts of the Stratocruiser and pointed out its luxurious double-deck passenger accommodations and the intricacies of the pilot's cockpit on the flight deck.

This tour was an interesting follow-up to the I.A.S.-sponsored movie shown at the school in December. Entitled *The Story of the Stratocruiser*, the film described the growth of the design from the experience gained in the development of the Boeing B-17 and B-29.

ERRATA

The picture of **Everett B. Schaefer,** published on page 26 of the March REVIEW, was mistakenly identified as that of **William B. O'Neal.** The correct caption is printed below. We apologize sincerely to both men for any embarrassment this error may have caused.

CHIEF TECHNICAL ENGINEER

Everett B. Schaefer, A.F.I.A.S., has been appointed Chief Technical Engineer of Canadair Ltd. Veteran of 20 years in aviation engineering, Mr. Schaefer resigned from Boeing Airplane Company to be in charge of Canadair's preliminary design section and stress, aerodynamic, and weight departments.

The present position of **William B. O'Neal,** M.I.A.S., is Chief of Design Sections for Canadair Ltd. Mr. O'Neal left The Glenn L. Martin Company where he was Senior Design Engineer. At Canadair he is responsible for direction of the design sections in the Engineering Department.

News of Members

Robert F. Beauvais, M.I.A.S., is Director of External Relations of S.N.E.C.M.A., Paris, France, manufacturer of aircraft engines. Previously he held the position of Chief Engineer.

Gordon D. Brown, A.M.I.A.S., has announced acquisition of manufacturing and distribution rights for the Load-Set Weblock, cargo tie-down system recently developed by the CJW Corporation of North Hollywood, Calif. The transaction includes purchase of the CJW Corporation's tooling and inventory.

Leo J. Coers, Jr., T.M.I.A.S., is now employed in Detail Engineering, Chance Vought Aircraft Division, United Aircraft Corporation, Dallas, Tex. Previously, he was Junior Engineer "B" with the Boeing Airplane Company.

Don K. Covington, Jr., M.I.A.S., has been advanced from Assistant Sales Manager to Sales Manager of the General Offices of The Harbor Sales Company, Inc., Baltimore.

Thomas W. Craig, T.M.I.A.S., resigned from Douglas Aircraft Company, Inc., Santa Monica, in September, 1949, to enter the College of Engineering at U.C.L.A.

Jean F. Duvivier, T.M.I.A.S., is Assistant Personnel Manager, Sears Roebuck, S.A., Rio de Janeiro. Although not affiliated with an aircraft company, he is working on his own design.

Irving Kolbin, T.M.I.A.S., has left Horle Arms Company of Deep River, Conn., and is now in the employ of Hamilton Standard Division, United Aircraft Corporation, as Detail Layout Engineer.

James U. Kordenbrock, T.M.I.A.S., is working in the Structures Department of Bell Aircraft Corporation as Senior Stress Analyst. He comes to Bell Aircraft from The Glenn L. Martin Company, where he was Senior Test Engineer.

Edward A. Ledeen, M.I.A.S., has become Dayton Representative of Taller & Cooper, Inc., Brooklyn, N.Y., manufacturers of wind-tunnel balances.

David B. Lillback, T.M.I.A.S., has been promoted to Assistant Chief Draftsman, Leviton Manufacturing Company, Brooklyn, N.Y.

John R. Meyer, Jr., T.M.I.A.S., formerly a Graduate Student, is now Research Engineer at M.I.T.

NEW P. & W. ASSIGNMENT

Perry W. Pratt, M.I.A.S., recently appointed Assistant Chief Engineer, Pratt & Whitney Aircraft Division, United Aircraft Corporation, has charge of design and development of all P. & W. advanced engines. With the Division since 1937, Pratt has been closely associated with development of jet and propeller-turbine aircraft engines.

NAMED CHIEF ENGINEER

Roy J. Sandstrom, A.F.I.A.S., has been appointed Chief Engineer of Bell Aircraft Corporation. Since May, 1948, Sandstrom has functioned as Executive Chief Engineer. Previously he was Chief of Bell's technical services and Project Engineer on the supersonic X-1. He has been associated with Bell Aircraft since 1938.

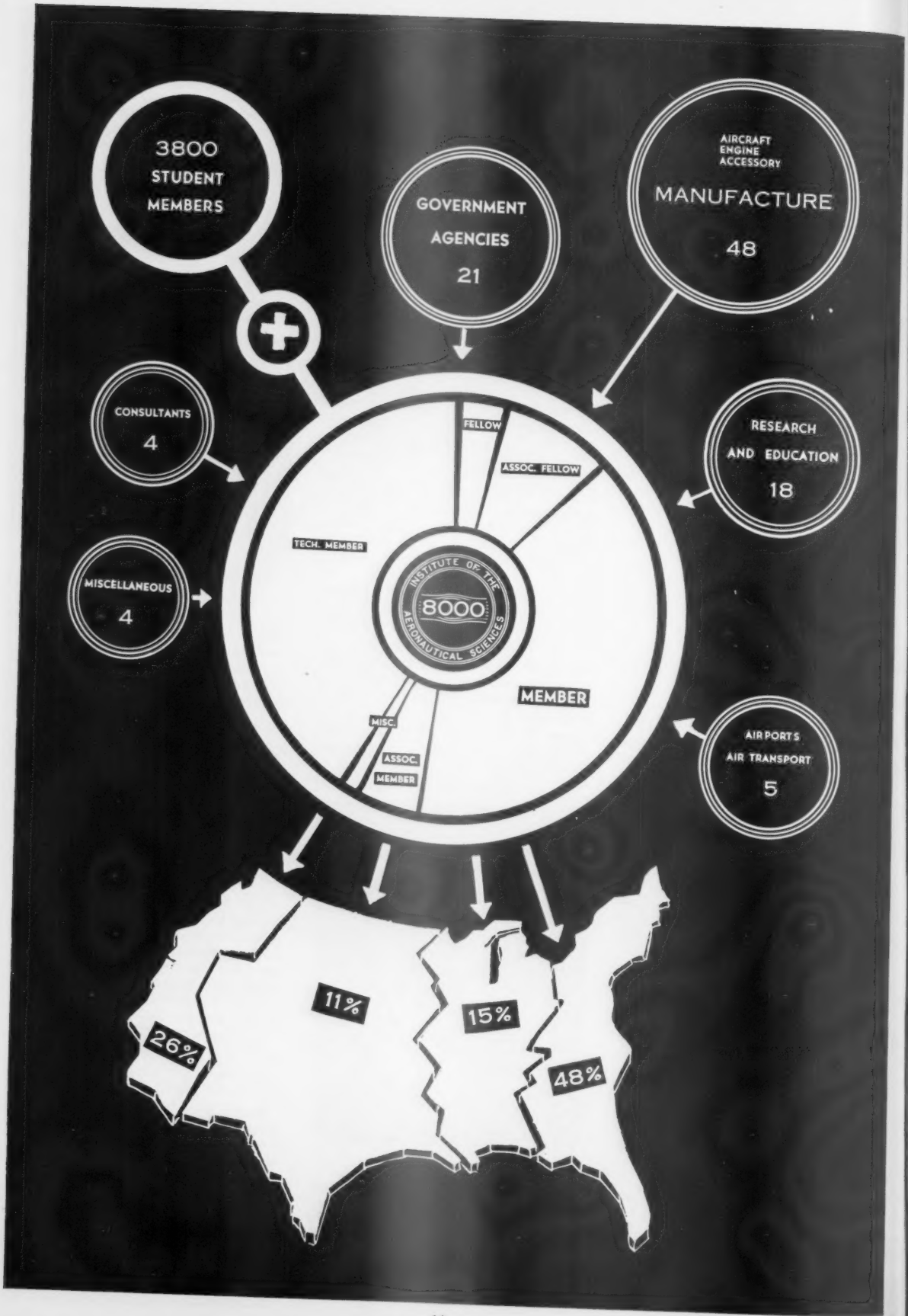
Philip L. Michel, M.I.A.S., has been appointed Associate Professor of Aeronautical Engineering at the State College of Agriculture and Engineering of the University of North Carolina. His previous position was Aerodynamicist, Grumman Aircraft Engineering Corporation.

Major C. C. Moseley, A.M.I.A.S., previously President of Grand Central Airport Company, is now Chairman of the Board of Directors of that company.

Paul H. Peck, T.M.I.A.S., is Application Engineering Data Editor for The Foxboro Company, Foxboro, Mass., manufacturer of industrial instruments. His previous position, Technical Copywriter and Copy Chief, was with Spencer Curtiss, Inc., Indianapolis.

John R. Rhoads, T.M.I.A.S., is Engineering Draftsman "A" at the El Segundo Plant of Douglas Aircraft Company, Inc.

(*Continued on page 99*)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Editorial

Object—Objectivity

During the past several months two attempts have been made to use membership in the Institute in a manner that is definitely out of bounds from the standpoint of policy. One involved a petition to a Government agency requesting an allocation of funds for a specific purpose. The other was a solicitation for support of a candidate for political office.

Both cases, we are certain, arose from a misunderstanding of Institute purposes and objectives. Their authors apparently were not aware of the harm to the Institute implicit in their actions. In each, however, it was necessary for us to make it clear to those involved that it is not I.A.S. policy, as an organization, to seek special advantages from Government agencies or from an electorate. Such matters fall outside the scope of our Charter, our Constitution, our customs, and our intentions.

To avoid such unfortunate complications in the future, it may be well to review our objectives and to reread our Constitution and By-Laws.

The basic mission of the Institute is to facilitate the interchange of ideas among aeronautical engineers to advance the aeronautical sciences. Our charter states that we may do "all and every act necessary, suitable and proper" toward that end, "provided the same is not inconsistent with the laws under which (the Institute) is organized.... " Further, the By-Laws under our Constitution provide that we "shall not endorse commercial enterprises" and that I.A.S. members shall use Institute facilities and associations only "in professional work."

Beyond all that, long-standing custom, good taste, and good management of I.A.S. affairs dictate that we shall always maintain the most objective possible attitude with respect to the promotion of specialized interests that may be of questionable value in advancing the arts and sciences of aeronautics.

A number of our members have taken occasion to comment on the specific cases of deviation from the above which recently came to light. We have replied to them as individuals, stating our views as outlined, but we felt that, for the benefit of others who may have been disturbed but who did not write, we should restate clearly the objectives and the policies of the Institute in such matters.

We have never departed from the purposes that are defined in our Charter. We have no intention of doing so. We hope that the membership at large will be guided by these principles so that there may be no cause for misunderstanding in the future.

S. P. J.

WHO, WHAT, AND WHERE OF I.A.S. MEMBERSHIP. **(Figures in circles are per cents of total U.S. Members, unless otherwise noted.)**

Impressions of the I.A.S. Eighteenth Annual Meeting—Part II*

DR. STEPHEN J. ZAND†
Lord Manufacturing Company

A PAPER ENTITLED, "The Transient Temperature Distribution in a Wing Flying at Supersonic Speeds," by Joseph Kaye, Associate Professor, Mechanical Engineering, Massachusetts Institute of Technology, involving considerable thermodynamics, was the third Aerodynamics paper presented. The lecture was crisp, which is not a surprise; professional teachers, in order to keep their tenures, must acquire a good presentation technique. The paper is concerned with the fact that if an object is required to fly steadily at an altitude, say, of 50,000 ft. and at a speed of 5,500 m.p.h. (Mach Number 8) the temperature of the surface of the object will be of the order of 4,000°F. Naturally, such temperatures will create a host of complicated problems for the designer, and the knowledge, either theoretical or approximate, of transient temperature distribution within the vehicle will provide guidance of unestimable value to the designing engineer.

The author presents in digest form the work done on the collecting of data pertaining to heat transfer coefficients. He concludes rightly that for velocities, Mach Number <0.4, the state of the art is well advanced but that for high subsonic speeds and supersonic speeds little factual material is available. He then develops the differential equation of temperature distribution in the wing (two-dimensional temperature distribution) and proceeds to numerical calculations. He finally reaches the following logical conclusions:

Calculations of heat flow in two dimensions for a wing flying at supersonic speeds with boundary conditions dependent on time from a Mach Number of 1.4 to one of 6 have shown the following:

(1) The leading and trailing edges of the wing are the most severely affected by aerodynamic heating.

(2) The temperature distribution in the wing is a function of time of flight.

(3) The temperature gradients at a Mach Number of 6 are considerably larger in the vertical direction than in the chordwise direction.

(4) The flow of heat could be approximated with small error by one-dimensional flow.

Calculations of heat flow in one dimension with boundary conditions dependent on time—namely, perpendicular to the chord—have shown the following:

(1) The error made in assuming heat flow in one rather than in two dimensions is negligible for thin wings for practical purposes.

(2) The effects of variable coefficients of heat transfer, or variable acceleration, and of size of network have to be examined.

These calculations are strongly dependent on the state of the art of heat transfer at supersonic speeds. Since the state of the art is poor, much experimental work is needed to verify the basis of these calculations.

Finally, these calculations of transient temperature distribution in the wing form the basis for the calculations of thermal stresses and aerodynamic deflections of the wing.

Papers such as "The Characteristics of Supersonic Wings Having Biconvex Sections" by Beverly Beane, of the United Aircraft Corporation's Research Department, are hard to present and equally difficult to review, since their content is based largely on the development and application of mathematical theories. Miss Beane's paper requires deep concentration but is well worth it. It is a notably original work. Fortunate and valuable for the student of both pure and applied mathematics is the fact that the author carried out certain integration with all intermediate steps in an orderly manner. She cites the numerous references to the characteristics of supersonic wings having a double-wedge section and points out that little has been published on the characteristics of such wings with biconvex sections. Solutions representing linear approximations for such wings are compared with wings having a double-wedge section, and the advantages of each design are discussed. Also presented is the comparison between the two configurations, and an analysis of the theoretical and experimental data concludes the paper. The list of 32 references appended to the paper shows how much background an author must have to produce such an interesting treatise.

Dr. A. M. Kuethe was in the chair during Aerodynamics—2. His remarks at the beginning and end of each paper were witty and to the point. The first paper, "On the Stability of Two-Dimensional Smooth Transonic Flows" was presented by Prof. Y. H. Kuo of Cornell University. Unfortunately, because of microphone trouble, Professor Kuo's voice did not carry well in the room, so many of the fine points of the treatise were lost to the audience. The paper

* Part I of this article appeared in the AERONAUTICAL ENGINEERING REVIEW, Vol. 9, No. 3, p. 34, March, 1950.

† Vice-President in Charge of Engineering.

deserves serious study, for the author has a profound grasp of the subject.

His study leads to the conclusion that (1) smooth transonic flows over symmetric bodies are unstable to pulses with sufficiently long initial "wave lengths" and given "shock strength"; and (2) those over unsymmetrical bodies are stable to all pulses with arbitrary initial "shock strength" and "wave length" as long as the slope of the body at the deceleration-to-sonic point is positive, if the body curvature is negative.

"First- and Second-Order Theory of Supersonic Flow Past Bodies of Revolution" by Milton Van Dyke, California Institute of Technology and The RAND Corporation, is another mathematical paper of general interest. First approximation can be obtained by the Kármán-Moore method, the author tells us; he has found also that he can write, in terms of the known first-order solution, a particular integral of the second-order iteration equation. The second-order solution is compared with the exact solution for the cone and with solutions obtained by the graphical method of characteristics for cone-cylinder bodies, ogives, and open-nosed bodies of revolution. In each case, the second approximation gives a great improvement over the first.

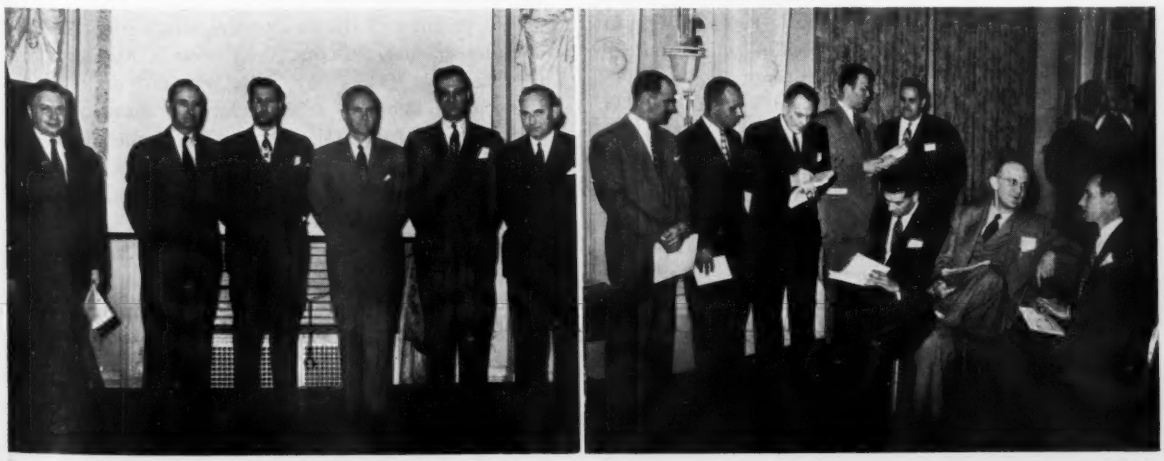
For inclined bodies of revolution, it appears that a solution sufficiently accurate for practical purposes can be obtained by combining the second-order solution for zero angle with the first-order solution for the cross flow.

Having absorbed two mathematical papers, one welcomed "The Rolling-Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Lifting Wings" by John R. Spreiter and Alvin H. Sacks, Ames Aeronautical Laboratory, N.A.C.A. Following the universal inclination to flow from high-pressure to low-pressure regions by every available path, the air escapes around the tips of airfoils and sets up a rotational flow that persists far downstream, behind the airfoil. Such flow is commonly known as tip vortex. In the first part of their paper the authors present a theoretical analysis based on the differential equation for the perturbation velocity and obtain useful formulas for different span loadings. The second spectacularly interesting part describes the experimental studies conducted by driving a model wing vertically into the tank at a constant velocity and photographing the water surface with a motion-picture camera. The trace of the trailing vortex sheet was made visible by applying fine aluminum powder to the trailing edge of the wing before each run. The distance of the model below the surface was indicated on each photograph by the position of a moving tape. The models were of 8-in. span and had flat-plate profiles, except for rounded leading edges and sharpened trailing edges.

One recalls that in the middle thirties Dr. H. C. Dryden, then a member of the National Bureau of Standards, did a great deal of basic research on problems of turbulent subsonic flow using the hot-wire anemometer as the basic tool. The problems of turbulent flow at transonic and supersonic velocities are of equal interest, and, of course, the question arises whether the same techniques and instruments can be used with the high speeds encountered today. Such an analysis is presented in "The Hot-Wire Anemometer in Supersonic Flow" by L. S. G. Kovasznay, Assistant Professor of Aeronautics, The Johns Hopkins University. According to the author, a direct adaptation of the subsonic technique seems impossible, and a number of fundamental problems must be solved before the hot wire can be considered a satisfactory instrument in the supersonic field.

Systematic experiments were conducted to determine the law governing the heat loss from a hot wire in a supersonic flow up to Mach Numbers of 2.0. It was found that the heat loss, expressed in the form of a Nusselt Number, is a unique linear function of the square root of the Reynolds Number when all dimensionless quantities are evaluated, not at free-stream conditions but behind a normal shock. This law is valid only in the case of small temperature loadings. For large temperature differences a nonlinearity appears

Speakers at the Air Transport and Jet Installation Design Sessions.



in sharp contrast to King's law, which has been found to be linear with temperature difference over a wide range of temperature loadings.

A second problem to be solved is that of obtaining adequate frequency response of the hot-wire equipment in order to resolve the turbulent fluctuations in space which are swept by the wire at high velocity in a supersonic flow. Encouraging progress has been made in using extremely fine wires and in developing electronic equipment that will compensate for the thermal lag of the wire at very high frequencies with no interference from noise.

The third problem that has been encountered is that of interpreting the hot-wire fluctuations when the number of flow parameter is large. Velocity, density, and temperature all contribute to the hot-wire reading, and it is believed that in some cases these effects may be separated.

Wright Brothers medalist, C. E. Pappas, of Republic Aviation, was chairman of the final aerodynamics session (Aerodynamics—3) and discharged his duties firmly, so that the session, an evening one, finished with sufficient spare time to permit the participants to indulge in a well-deserved nightcap. The first of this series of papers, "Periodic Motions of a Rectangular Wing Moving at a Supersonic Speed," by T. Y. Li and H. J. Stewart, Professors of Aeronautics, California Institute of Technology, was interesting from a mathematical point of view, since the authors computed the periodic motions to which aerodynamic forces and moments of a rectangular wing moving at supersonic speed are subjected. The method is an extension of similar theories dealing in the realm of subsonics and gives results that can be expressed in dimensionless coefficients. This reviewer thinks that the linearization of the nonsteady flow theory, while a good beginning, should be carefully analyzed, since the answer might be closer to observed phenomena if one would not linearize but use principles of nonlinear mechanics; topological methods should perhaps be considered.

Linearization—this time of the lifting surface theory—is in the work of Charles W. Frick, Ames Aeronautical Laboratory, N.A.C.A., who in his paper, "The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed," investigates bending and torsional deformation under supersonic conditions.

In view of the promising flight efficiencies of swept wings, the analytical investigation was extended to include the stability characteristics of these wings. The changes in stability, due especially to the elastic deformation of the wing, were thought to be of major significance, since it was recognized that the structural weight penalty necessary to overcome these adverse aeroelastic effects might easily outweigh the aerodynamic advantages. The present investigation was therefore undertaken to provide estimates of the aerodynamic effects of the elastic deformation of the wing panels. The extent of the present paper is limited to the treatment of longitudinal stability. Accelerated flight conditions only are investigated, since the longitudinal stability of the aircraft has greatest significance in dynamic flight. Terminating the paper is an extremely interesting appendix in which the authors develop a mathematical derivation of loading functions and plan-form constants. While the analytical derivation—essentially a solution of a definite integral—is masterfully done, it appears that a graphical evaluation would be sufficiently accurate and give much less chance for algebraic or arithmetical error.

Ballistics and aerodynamics found a common ground when guided missiles became a reality. An example of the merger of the two sciences was furnished by a paper entitled "A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile" by R. E. Bolz, Assistant Professor, Rensselaer Polytechnic Institute, and John D. Nicolaides, Aerodynamicist, Ballistic Research Laboratories. The paper, well documented and presented in a lively manner, describes the determination of the motion of a missile from successive photographs during free flight down the ballistic range. The data are smoothed out by the method of the least square; the equations finally yield the experimental values of the aerodynamic coefficients. This method can be applied to any type of motion; this paper treats simple pure roll. A fine beginning of the use of a powerful research tool.

This reviewer has a quarrel with Leonard Meyerhoff, Research Associate, Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn. What excuse is there for presenting a fine piece of research work, promising to send the manuscript to the editor, and then promptly forgetting about it? The one who reports on some 40 or 45 papers cannot possibly take the salient features of all the presentations in shorthand and then, without looking at the manuscript, prepare an intelligent review of them. Let us also not forget that many sessions take place simultaneously. Fortunately, this reporter attended the presentation of Mr. Meyerhoff's paper and admired it greatly. The lecturer was probably the first scientist to give numerical solutions of the complete system of the Navier-Stokes equations and heat-balance equation for the problem of the shock-wave structure in a steady one-dimensional, viscous heat conducting and convecting flow. This, naturally, was not done by the classical "longhand" method, and it emphasizes the versatility and usefulness of the electronic differential analyzers. To appreciate Mr. Meyerhoff's paper even more, it would be well to refer to *Supersonic Flow and Shock Waves* by Courant and Friedrichs, a book that probably served as a valuable guide for the writing of this paper. It is hoped that the AERONAUTICAL ENGINEERING REVIEW or the JOURNAL OF THE AERONAUTICAL SCIENCES will publish Mr. Meyerhoff's work in an early issue, but this cannot be done without the manuscript!

It must be a great satisfaction to act as chairman of a session when one is a top exponent of the given branch of aeronautics. M. Goland, Chairman, Engineering Mechanics Division, Midwest Research Institute, pre-

sided during the Aeroelasticity Session, attended by a capacity audience. The first paper, "A System for the Excitation of Pure Natural Modes of Complex Structure" by Robert C. Lewis and Donald L. Wrisley, Department of Aeronautical Engineering, Massachusetts Institute of Technology, was carefully planned, beautifully illustrated, and so ably presented that it reflects great credit on the authors and on the institution they represent.

It is not sufficient in modern aircraft to analyze structures statically; a dynamic analysis is also necessary. The paper reviews the methods available and describes the electrodynamic methods used for producing the necessary excitations.

The authors conclude their paper by pointing out that coordinated instrumentation is now available for the experimental evaluation of the pure modes of complex structure. The equipment has been made as simple in operation as possible under the complex requirements of its use.

They also show that the multiple shaker system may be adjusted to excite pure natural modes in accordance with a simple procedure, utilizing an automatic normalizer and signals readily interpreted as to phase, frequency, and amplitude on a cathode-ray oscilloscope.

If and when this method, which is based on a simplified assumption of damping distribution, fails to produce a pure mode, it will be evident on the directly recorded data. In such cases the adjustments may be modified with full ability to evaluate the effects on the structure.

The paper, "The Solution of Aeroelastic Problems by Electronic Analog Computation" by Jonathan Winson, in Charge of Dynamics, Guided Missiles Division, Fairchild Engine and Airplane Corporation, created a great deal of interest because it showed that the utilization of a mathematical machine is the converse of the usual application of mathematics. Ordinarily, one has a natural (physical) system, and what is wanted is a mathematical analysis. One endeavors to find a set of mathematical concepts in terms of which the system can be described. In an analog machine, however, it is the mathematical concept that is given, and a natural system is set up which realizes these concepts. Mr. Winson uses as an example flutter and related aeroelastic phenomena, but the analog method is applicable to many problems; it is of tremendous value in dynamic stability investigations as the classical solution of quartics, quintics, and sometimes sextics encountered in this work is highly time-consuming.

A paper on "The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes" by R. H. Scanlan, Associate Professor of Aeronautical Engineering, and John C. Truman, Rensselaer Polytechnic Institute, was valuable because the figures describing the gyroscopic effect were spectacular. Open to question in this paper, however, is the assumption that a rigid engine mount is always used, transmitting all the gyroscopic and vibratory forces directly to the aircraft structure. Today, all engines are flexibly mounted, and the effect of gyroscopic precession on the aircraft structure is practically eliminated by the yielding flexible supports. Thus, the assumption of a rigid propeller-engine-wing structure combination is only interesting from the theoretical point of view, since it does not represent conditions encountered in actual airplanes.

One branch of applied mathematics which especially fits the needs of the scientific aeronautical engineer is "matrix calculus." The matrix operations represent a powerful method for the solutions dealing with mechanical systems with a certain number of degrees of freedom. It is interesting to note that matrix calculus is about a century old, but its introduction to aeronautical engineering dates only from about 1935. For this reason many engineers did not have a formal course in matrix calculus, and these will miss the fine analysis entitled "A Recurrence-Matrix Solution for the Dynamic Response of Elastic Aircraft" by John C. Houbolt, Langley Aeronautical Laboratory, N.A.C.A. By means of the matrix calculus, Mr. Houbolt studies the structural response of the airplane when flying through gusts. He develops a recurrence relation that permits step-by-step calculation of the response and, consequently, of the loads that occur on the structure. Despite the fact that the subject matter was probably thoroughly understood by only a minority of the audience, presentation in true N.A.C.A. fashion made many engineers hasten back to the library for an introductory course on matrices. This reviewer believes that matrix and tensor calculus should be taught more widely to the aeronautical engineer, since the time-saving in the solutions of dynamic problems will amply repay the few months of training necessary to acquire proficiency in this branch of mathematics.

While theoretical and practical knowledge of aerodynamics always receives a lion's share of the time allotted to meetings, other branches of aeronautics are not forgotten. A session on Structures, under the chairmanship of Ira G. Hedrick, Chief of Structures, Grumman Aircraft Engineering Corporation, was extremely well attended and rewarding.

The first paper, "An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads" by E. E. Sechler, M. L. Williams, and Y. C. Fung, Guggenheim Aeronautical Laboratory, California Institute of Technology, investigated the stresses of thin swept wings. The paper gives an account of the theoretical, experimental and electrical analog methods used in this work. The authors had to devise an idealized way in using a thin cantilever plate of uniform thickness under normal loading. A great deal of published material on the behavior of such plates exists, and the Rayleigh-Ritz method can be applied to such a system. The electrical analog is extremely well worked out, and the remarks made elsewhere on this method fully apply to this paper.

"Column Behavior in the Plastic Stress Range" by John E. Duberg and Thomas W. Wilder, III, of the Langley Aeronautical Laboratory, N.A.C.A., presents a

summary of the significant findings of a theoretical study of the behavior of such designs in the range of plastic stress. The authors point out that this work was inspired by a paper presented by F. R. Shanley in 1947, and their work is an extension of this treatise. Three important conclusions are presented, and it is expected that stress engineers will profit from the logical presentation of the subject.

"Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities" by P. P. Bijlaard, Associate Professor, Cornell University, was the last paper read during this session, and it deals with the derivation of a formula for the critical thrust for antisymmetrical buckling of sandwich plates. In his introduction the author calls it a simple derivation of a formula, but the reader will note that knowledge of partial differential equations is necessary in order to follow the 83 or so intermediate steps that are requisite to develop this formula; however, the presentation is orderly and, in spots, brilliant. Since the results are immediately applicable to certain laminated structures that are gaining popularity at an astounding rate, the paper should be carefully studied.

A. M. Freudenthal's lecture on "Types of Inelasticity of Structural Materials and Procedures of Design" was undoubtedly the highlight of the structural series of papers. Apart from the fact that Professor Freudenthal's presentation was of a high standard, his dissertation was valuable in that he pointed out that more fundamental knowledge pertaining to interatomic and nuclear forces of materials is necessary to produce lightweight, safe, airplane structures.

Conventional stress analysis of engineering structures constitutes only one phase of the necessary treatment; of equal importance is the prediction of the effect of those stresses on the unified design. Usual design analysis assumes that the behavior of materials is characterized by an adherence to the classical laws of elasticity and that recognition of such laws suggests the essence of good design procedure. Such assumptions neglect the important fact that the ability to "yield," in the correct, equalizing, inelastic manner, of an engineering structure constitutes a characteristic of a material which is of even more importance than ultimate fracture strength. It is recognized that few designs provide a uniform resistance of all structural parts to an applied load and that certain component sections usually experience a limiting resistance before such a limit is reached in the structure as a whole. This limiting resistance may be expressed in terms of a critical separation stress, a condition of unstable equilibrium, a limiting deformation, or a limiting stress or strain characteristic of reversible to irreversible transitions. The expression of a limiting condition in terms of fracture or instability is usually suggestive of designing within the limits of the laws of elasticity. When consideration is given to the relationships between local yielding and mass structure yielding, however, the engineer must design within the laws of plastic behavior.

Engineering materials, made up of a large number of structural units (atoms, etc.), experience, in addition to the usual elastic and fracture changes, alterations associated with the viscous irrecoverable displacement of individual molecular units, the plastic irrecoverable displacement of groups of molecular units, and the force-independent thermally excited diffusion that may lead to changes of structure due to recrystallization and precipitation. Most materials possess regions of ordered and unordered structure, and their behavior under stress can therefore be described only by a complex combination of elastic, plastic, viscous, and diffusion responses. A knowledge of the microstructure of a material is especially necessary if macroinelastic response is to be correctly predicted. When the inelastic response of a design part and the type of loading determine the limiting design condition, one can classify design procedures as follows: (1) design for plasticity and work-hardening (associated with the plastic displacement of groups)—such designs are usually characterized by moderate temperatures and moderate loading rates; (2) design for creep (associated with the viscous displacement of individual elements)—these designs are characterized by elevated temperatures and sustained loads; (3) design for brittle fracture by impact; and (4) design for fatigue under finite repeated loads, associated with the work hardening of the metal.

Consideration of inelastic material behavior is also important in the field of experimental stress analysis; the effect of time is unfortunately not generally appreciated in stress-coat studies, and the inelastic deformation in metals, occurring even at very low stress, definitely limits the significance of photoelastic studies.

The Aircraft Design Session, under the chairmanship of the newly appointed Chief Engineer of The Glenn L. Martin Company, W. B. Bergen, attracted the attention of the many design engineers who attended the meeting.

The first paper, "Lateral-Control Devices Suitable for Use with Full-Span Flaps" by Francis M. Rogallo, John G. Lowry, and Jack Fischel, Stability Research Division, Langley Aeronautical Laboratory, N.A.C.A., gives a brief historical review of the development of the devices referred to in the title, with particular emphasis on spoiler-type controls on swept wings at high supersonic speeds. Some reference is made to the possibility of using such a construction on unswept wings. Advantages are discussed, and the conclusion is reached that the spoiler-type controls could be used on all types of airplanes. An interesting speculation is voiced by the authors as to the possibility of using spoiler ailerons simultaneously as ailerons and air brakes. It appears that the performance of such a combination compares favorably with the standard type of air brakes used today. As is usual with N.A.C.A. papers, the illustrations are perfect and a full set of references is given.

"The Influence of Design Parameters on the Performance of Subsonic Air Inlets" by Howard E. Rob-

erts, Group Leader, and B. D. Langtry, Aerodynamicist, Aero-Thermodynamics Group, Aerodynamics Section, El Segundo Plant, Douglas Aircraft Company, Inc., will certainly be a welcome addition to the rapidly growing literature on inlets and outlets of air or gases in both the supersonic and subsonic fields. In particular, the authors are wise in giving a complete nomenclature of the terms that are often vaguely used in this branch of applied aerodynamics. Essentially, the lecturers presented the results of an experimental investigation into the influence of design parameters on the performance of a certain class of subsonic air inlet. This class of inlet, normally located in the skin of the air frame, employs a boundary-layer bleed.

The influence of aspect ratio, degree of protuberance, ramp profile, boundary-layer thickness, and bleed position upon the inlet-total-pressure recovery, critical Mach Number, and boundary-layer-bleed-total-pressure recovery was determined. The results are summarized in the form of graphs and design charts that can be used by air-frame designers in the selection and design of air inlets that satisfy their requirements. The application of these results to practical design problems is also discussed.

The authors recommend that other researchers adhere to the following program:

(1) Systematic investigation of the influence of design parameters on the form drag of air inlets.

(2) Systematic investigation of the influence of inlet-total pressure (or velocity) profiles on the performance of duct components such as diffusers, bends, etc.

(3) Investigations of other basic inlet configurations in a systematic manner and the presentation of the results of these investigations in the form of design selection charts similar to those presented in this paper.

(4) Extension of above to the high subsonic, transonic, and supersonic speed ranges.

"Air-Line Pilot Questionnaire Study on Cockpit Visibility Problems" by Thomas M. Edwards, Structure Branch, Aircraft Development Division, C.A.A. (Indianapolis), is based on a questionnaire sent to 6,000 pilots, the answers classified in accordance with common statistical methods. The objective of the study was to provide a practical basis for cockpit visibility requirements as expressed by the average pilot's opinion. Naturally, whenever one deals with human beings, even with as many as this questionnaire reached, one has to be extremely careful in drawing conclusions, since many surveys of this type do not produce average results. Mr. Edwards either possesses a fine statistical sense or has had the advice of scientists versed in this art. His conclusions will no doubt be a guide to cockpit designers and give the pilots the visibility they need for safe and comfortable flying.

Jerome Lederer has spent all of his professional life in some phase of aviation dealing with safety. It was fitting and natural, therefore, that he was chosen as the Chairman of a session dealing with air transport, in which all the papers but one dealt with some aspect of improving the already excellent record of safety in air transportation.

"Service Testing of Prototype Air Transports" by W. E. Koneczny, Chief of Airworthiness Division, C.A.B., shows that present methods of proving the mechanical reliability in service of airplanes and their components are time-consuming, inadequate, and inefficient. To quote the author: "Today's satisfactory component may cause tomorrow's crisis." Many recall the serious supercharger difficulties developed by one of our most famous long-range airplanes, despite the fact that this craft was fully approved some 9 months previously, or the other case where another craft was grounded for several months, with tremendous loss of revenue to the air lines, because it was discovered that under certain circumstances leakage of fuel into the heater was possible. This was a stimulating paper. Even though a universal test procedure has not been found and probably never will be, thinking along the author's line may preclude the appearance of difficulties after many months of satisfactory performance. Papers of this type are of particular value to the designing engineer because they keep him alerted to the many hazards to which his constructions are subjected. Two papers followed dealing with fire: "Fire Out—By Design" by H. L. Hansberry, Power Plant Development Section, Federal Airways Experimental Station, C.A.A. (Indianapolis), and "Progress in Fire Prevention—Following Crash" by Lewis A. Rodert, Chief of Flight Branch, Lewis Flight Propulsion Laboratory, N.A.C.A. The authors emphasize the point that fire prevention could be best accomplished by the employment of less flammable fluids, but, unfortunately, the best fuels known today have a low flash point and burn readily when ignited. At present, satisfactory methods are indirect—as, for example, the location of flammable materials as far away from the fuel system as possible. In the construction of the airplane, the use of fireproof and fire-resisting materials is another good practice. The keynote of both authors was the emphasis on the fact that, to produce a satisfactory airplane, a great amount of research is necessary in connection with fire-detecting systems and fire-extinguishing means.

Engineers, in general, are so preoccupied with the technical details and the functional characteristics of their designs that they are often oblivious to the fact that their products are used by human beings and that, in case something goes wrong with their designs, a human being is either going to die or to be maimed for life. As long as people are being transported in any vehicle, complete elimination of accidents is not attainable. What can be done, however, is at least to build the airplanes or the vehicle in such a way as to answer affirmatively the following three questions:

(1) Are the present standards adequate on the basis of the record, and, if not, what level of protection is necessary?

(2) Can the human body, if supported, withstand deceleration forces of the magnitude indicated?

(3) Can the level of protection indicated as needed by the record be provided practicably?

That is the problem in essence of an excellent summary by William I. Stieglitz, Republic Aviation Corporation, entitled, "A Note on Crashworthiness." The discrepancy in specifications is emphasized and shows the following divergence of opinion: for example, the crash load factor of the C.A.B. is 6*g*, while that of the U.S. Navy is 40*g* and U.S.A.F. is 17*g*. Mr. Stieglitz comments on this wide discrepancy; then he thoroughly analyzes safety belt design. The conclusion of his paper is that it would be much safer to build airplanes in which the passengers face backwards. Which way one sits in an airplane is purely a matter of precedent and habit. This, the author points out, has been amply proved by statistical sampling of the R.A.F. Transport Command, from which the statisticians conclude that only one in five passengers objected to such an arrangement. Mr. Stieglitz concludes his paper with an interesting statement: "A reorientation of the attitude of the aircraft designer and abandonment of the polite fiction that transport aircraft do not have accidents are overdue. Accidents are still occurring, and there is nothing to indicate that they will not continue to occur in the forseeable future. It is reasonable that aircraft should meet crashworthiness, as well as airworthiness, requirements." A valuable set of references, which should be read by every Project Engineer and Group Leader, concludes this fine summary.

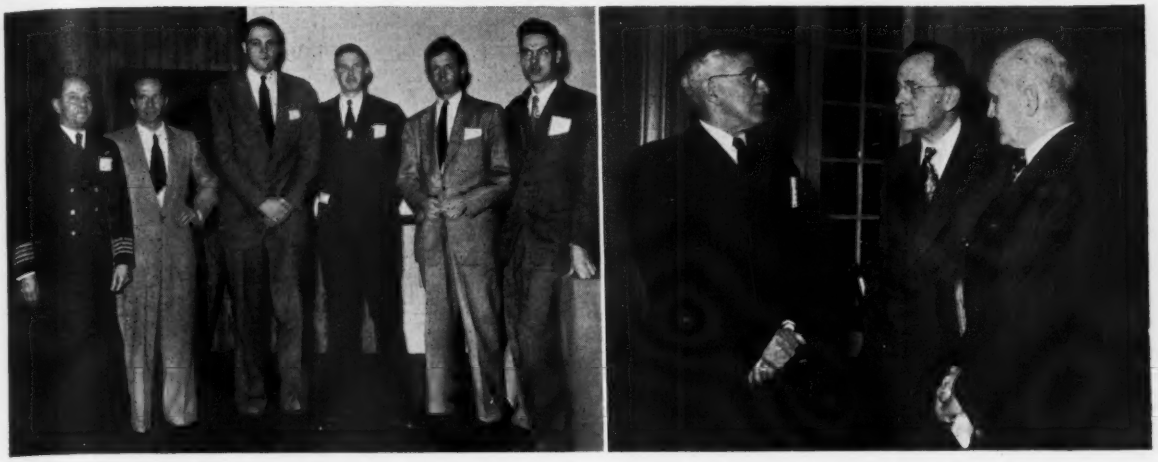
Since the publication some 5 years ago of the classical text, "Human Factors in Air Transportation," by Dr. Ross McFarland, strides have been made in understanding the reactions of human beings to the manifold physiological stimuli that are peculiar to air transportation. The work of E. R. Dye, Head of Development Division, Cornell Aeronautical Laboratory, Inc., entitled "Kinematic Behavior of the Human Body During Crash Deceleration," is of extreme value because it analyzes the mechanics of the human body during a crash. This has been done by means of a model called, by the author, "the thin man," and by comparison with the actual average man. Papers of this type should be encouraged, since, if accidents cannot be eliminated completely, at least every effort should be made to design components in such a way that, if an unfortunate mishap occurs, the bad effects on the human occupants will be held to a minimum.

The last of this series of papers, "Maintenance of Safety Attitudes in Air Transport Operation" by Robert Knight, Director of Safety, American Airlines, Inc., was a narrative account of the many maintenance and safety features used in air-line operation, and one can only voice admiration for the thoroughness with which most air lines emphasize the word "safety." As the author himself says: "All air-line operations involve safety skill and safety attitudes—from the officers of the company to the night watchman." Obviously, when the word "skill" is used, this means education and training. The author points out that training by bulletin board announcement, visual aids, aural aids, motion pictures, slides, and incentive pay are commonly used to increase the already high safety record.

The symposium on jet installation problems, a well-prepared symposia, suffered only from the fact that it had to be terminated at 5 o'clock. Under the able chairmanship of S. T. Robinson, of Sanderson and Porter, the session was meaty and vigorous. Two formal papers were presented dealing with power plants: "Primary Power Plant" by John Karanik, Chief Power Plant Installation Engineer, Grumman Aircraft Engineering Corporation; and "Systems and Accessories" by John S. McCarthy, Power Plant Engineer, McDonnell Aircraft Corporation. From these one must conclude that the art of installing power plants in jet airplanes or accessories on turbopropellers or on turbojets is still extremely young.

Servicing of turboengines requires special configurations of the human body (not yet invented). What is needed is an 8-ft. man, preferably without a spine but with four hands and not more than 15 in. across the shoulders. Both authors emphasize that lately the situation is getting better and better as airplane and turbine designers become better acquainted. An ideal power plant, just as an ideal accessory position, will never be found, but compromises that are satisfactory to all branches of engineering will be reached as the development of jet engines progresses. The discussers: M. C. Benedict, Aviation Gas Turbine Division, Westinghouse Electric Corporation; Dimitrius Gerdan, Allison Division, General Motors Corporation; R. E. Small, Aviation Gas Turbine Division, General Electric Corporation; Charles Jewett, Wright Aeronautical Corporation; Willard Gorton, Pratt & Whitney Division, United Aircraft Corporation, were well prepared, and they brought out clearly several points worth reporting on. What is the best method of starting a turbine, and what time is necessary to accomplish it? It seemed to be the consensus that the long-forgotten cartridge (shot-gun shell) starter, delivering about 100 to 150 hp. would be the best, and that, if such a design is produced, it should be equipped with three cartridges —one for a miss, one for a true start on the ground, and one for starting at altitude. Starting time should be about 5 to 10 secs. Another opinion was voiced that a hydraulic starter could be used to advantage, since at the present time, hydraulic accumulators of 2,200 lbs. per sq.in. pressure and motors of 85-hp. capacity are available. The amount of oil necessary to produce satisfactory starting would be 10 gal. for a start on the ground and $2^1/_2$ gal. for starting at altitude.

The details of cooling the exhaust came under vivid discussion, and methods of installation were ably presented by several members of the panel. Another topic received considerable attention, but it seemed that the opinion on it has not yet crystallized. The question was: "Should we bleed compressed air for cabin supercharging and also drive certain accessories using the main compressor as the source of compressed air?" Mr. Small, of the General Electric Company, brought out a point that nearly stopped further dis-



Meteorologists—Some of the Speakers at the Joint Sessions with the American Meteorological Society.

cussion—namely, "in doing so, the thrust loss of $2^1/_2$ per cent can be expected when a 10 per cent extraction of air is contemplated, while if one sacrifices 100 mechanical hp., one would lose only $^1/_2$ per cent of the thrust." Many other topics came under scrutiny, and this reviewer regrets only that he is too old to change the branch of his profession and join the group that installs turbojets in high-speed aircraft. The problems in turbojet installations are exciting and fascinating, and also, as evinced by the good humor of the lecturers and the discussers, they are a lot of fun.

Flying boats have had their ups and downs in the history of aeronautics. Until recently, new models were built at but rare intervals, probably because of the fact that the advancement of hydrodynamic hull designs did not keep pace with the vast knowledge acquired in aerodynamics and propulsion. Fortunately, the leading hull designers realized that they must improve their techniques, with the result that outstanding progress has been made lately in the design of flying boats. This fact is amply demonstrated by a startling paper by Ernest G. Stout, Assistant to the Chief Engineer, Consolidated Vultee Aircraft Corporation, entitled, "Development of High Speed Water-Based Aircraft." The salient features of this paper are the explanation of how research employing dynamically similar models has been used and how new seaplane design criteria have been developed. Mr. Stout assures us that new research tools are available so that a seaplane can be built today which will satisfactorily meet or exceed all modern requirements. Despite the fact that the presentation of the paper conflicted with another one of unusual interest—Dr. Langmuir's lecture on the making of rain—Mr. Stout had a large and appreciative audience. The presentation matched Mr. Stout's previous appearances before his many friends and admirers.

The session dealing with Meteorology was well attended and during the presentation of some of the papers, standing room only was left.

Meteorology—1, under the chairmanship of Capt. H. T. Orville, U.S.N., contained four papers that indicate that meteorology is evolving from an art into a science. Even to mere amateurs like your reporter, who knows only the difference between an isobar and an isotherm and who can distinguish a cirrus from a cumulus cloud, modern meteorology is a fascinating subject—to those who are adept at it, it must be a magic realm.

The first paper, "Observations and Theory of Flow over Long Ranges," by Joachim Kuettner and Philip Duncan Thompson, Atmospheric Analysis Laboratory, Geophysical Research Directorate, AF Cambridge Research Laboratories, deals with mother-of-pearl clouds and provides a qualitative description of the flow from the analysis of soaring flights that went as high as 35,000 ft. The data thus collected are extrapolated up to 80,000 ft. and are further substantiated by the use of radar. A considerable amount of mathematics is used, and exact integrals of the Bernoulli and vorticity equations are derived from the nonlinear equations governing the steady flow of an ideal gas. Density may be eliminated between those integrals to obtain a generalized flow equation, involving only the momentum stream function and valid for any distribution of wind and temperature in the region of undisturbed flow. This paper is of such unusual thoroughness, so ably written, and so well presented that it is hoped that it will be read in its entirety not only by meteorologists but also by many aerodynamicists.

A practical approach to a highly theoretical subject was made by Prof. Holt Ashley and Donald Nielson, Department of Aeronautical Engineering, Massachusetts Institute of Technology, in their paper entitled, "The Influence of Wind Gradient and Unsteady Flow Effects on Short Take-Off Runs." The authors investigate the loss of lift due to unsteady flow effects. Here, too, it may be said that the authors have successfully combined art and science. The calculations are based on collected data and the important effect of head winds in counteracting the lift loss is demonstrated. The real

influence of vertical wind gradient on the rate of climb after take-off is also ably analyzed.

Two other papers followed: "Vortex Thermometer for Measuring True Air Temperatures from an Airplane" by Bernard Vonnegut, General Electric Research Laboratory, and "The Measurement of Temperature in the Presence of Water Particles" by Patrick J. Harney, Department of Meteorology, Massachusetts Institute of Technology. Both papers dealt with the proper design and location of thermometer housings for the measurement of free-air temperatures. In essence both the papers dealt with the question: "How wet is the wet bulb?" It appears that this is a most important question for accurate measurement of air temperature.

Captain F. W. Reichelderfer, U.S.N.R., Chief of the U.S. Weather Bureau, presided over Meteorology—2. This session drew the greatest amount of newspaper comment and provoked some superheated discussion. The reason for the excitement will be left for the final comments in this review. The session got under way with "Results of Recent Investigations of the Meteorological Conditions Conducive to Aircraft Icing" by William Lewis, U.S. Weather Bureau. Comment on icing of aircraft is always of interest to airplane designers and airplane users. The author has made a deep study of the various conditions under which ice can form and concludes that icing conditions in the upper portions of large cumulus congested clouds are much more severe than any encountered in other cloud types but that, because of their limited horizontal extent, flight in such conditions can usually be avoided. Icing conditions in stratus and strato-cumulus clouds are usually light or moderate in intensity but constitute one of the chief icing hazards to airplane operation because of their large horizontal extent. Ordinarily, significant icing conditions do not occur in alto-stratus clouds or in large areas of general precipitation because the presence of ice crystals prevents the formation of liquid water drops.

Just as the next speaker was approaching the microphone, your reviewer was joined by a V.I.P. who, arriving breathless at the session, asked him whether the paper, "Radar RHI Scope Movies of a New England Storm" by Myron G. H. Ligda, Department of Meteorology, Massachusetts Institute of Technology, had been presented, since he had heard that it was going to be an extremely interesting one. Unfortunately, the V.I.P. was disappointed. The author started with an apology that sequence photography of radar screens is a new art, not yet fully developed, and that he (the author) had seen this film some 15 times and at each showing had discovered some new features. The audience, seeing it for the first time, saw nice blotches, slightly out of focus, and the commentary of the speaker could be appreciated only by a person with a vivid imagination. Photographing radar screens is difficult, so it would have been well if the author had engaged a professional cinematographer who could have helped him with the choice of the type of film (the grain), the choice of lenses (large resolving power), and the method of properly framing pictures suitable for public showing. It is a good technique, and with greater attention to details it could have been a talk of considerable educational value.

The weather is an inexhaustible topic of conversation for all of us, and those who make their living off the land find in it the main source of their complaints. For the weather always sins by excess—it is either too hot or too cold, too wet or too dry. Whether he is conscious of it or not, the weather affects every human being; it determines the kind of clothing he wears; the type of dwelling he lives in; his methods of transportation; his means of livelihood; his recreations; his health, wealth, and happiness—in short, his whole life.

Therefore, a hush descended on the audience when the next speaker, Dr. Irving Langmuir, of the General Electric Research Laboratories, was introduced. For Dr. Langmuir is the only person who does something about the weather instead of just talking about it. Time was so short that in introducing the speaker the chairman had to omit the fact that Dr. Langmuir has to his credit 16 honorary doctorates and some 18 scientific medals, including the Nobel Prize for Chemistry, awarded to him in 1932. But a long introduction was unnecessary, for everybody knows of Dr. Langmuir's great achievements. The audience was also aware of the fact that this was the first time that a Nobel Prize winner had presented a special paper before the membership of the Institute. Despite his 69 years and his world-wide renown, Dr. Langmuir has the exuberance and infectious enthusiasm of a man half his years. A vigorous speaker, he spoke for 1 hour and 20 min. at the rate of some 200 words per min., rarely referring to notes. Dr. Langmuir insists that meteorology is a science and not an art. The title of his paper was "The Control of Precipitation from Cumulus Clouds by Employment of Various Seeding Techniques." He is convinced that his technique has produced several storms. Of course, the died-in-the-wool meteorologist always puts forth the argument: "It is true that it has rained after you have seeded the clouds, but how can you determine that it would not have rained anyway?" Such arguments are hard to win and equally hard to lose. Your reporter, for one, is convinced that Dr. Langmuir knows what he is talking about.

Dr. Langmuir said that the most effective methods of producing rain were through seeding supercooled clouds either with dry ice or with silver iodide. By these methods snow is produced that may fall as snow, may change to rain, or may evaporate—depending upon atmospheric conditions.

He said the use of dry ice was effective and cheap but that its successful use required air with below-freezing temperature. The use of silver iodide particles, which serve as nuclei upon which below-freezing water droplets in a cloud crystallize, does not involve such rigid atmospheric conditions.

With proper and complete data on weather and atmospheric conditions, seeding with dry ice would perhaps be the safest technique, according to Dr. Langmuir. With the other, he added, there is a danger of overseeding, which could create a drought.

The scientist also emphasized that need is felt for "meteorologists of the new school of thinking." He took issue with Weather Bureau scientists on the question of nuclei in the atmosphere and the possibility of introducing nuclei into the atmosphere to make rain as he and his associates had done. He said consideration of nuclei in the atmosphere would be an essential part of weather forecasting in the future. He added that much skepticism has greeted his work, because he offered only conclusions and what critics considered insufficient proof.

The paper was illustrated with excellent kodachromes and black and white pictures, which added greatly to the pleasure of listening to it. The lecturer was rewarded with a tremendous ovation. The chairman was embarrassed to notice that almost all the time allotted for discussion was gone, he therefore declared that only 3 min. per discusser would be allowed. That was unfortunate because it was evident that by this time the house was divided—half pro-Langmuir, half anti-Langmuir. For example, a member of the Conservation Department was perturbed about the many knotty legal problems involved in a rain-making project, such as control of rain in areas where this action would inflict damage on adjacent properties or the control of clouds moving across state lines or international boundaries. To this, Dr. Langmuir's reply was short and to the point. When it becomes necessary to control the weather for the public welfare, "new laws will be created when the problem has grown to that magnitude." He added that if funds are available in the next few years for the artificial increase of rainfall in certain areas, the investment would produce hundreds of millions of dollars of revenue by guaranteeing the maturity of crops whose success under present conditions is a matter of chance.

The meeting adjourned and most of us felt that Dr. Langmuir had earned the supreme commendation—"Well done, thou good and faithful servant."

Finale but Not Finis

The Eighteenth Annual Meeting is over, and the nineteenth is coming in only 9 months. Shall we sit, pat ourselves on the back, and merely say: "This was a fine meeting, let's make the next one just as good?" Such an attitude is "model-T-ism"—let's make the Nineteenth a still better gathering. This cannot be done without a little criticism. Of course your reporter fully realizes that, to quote an old French proverb, "La critique est facile, c'est l'art qui est difficile."*

* It is easy to criticize, it is the art that is difficult.

One can appreciate that the choice of subject matter for the meeting must be a difficult chore for the committee. No one enjoys applied mathematics more than this reviewer, but to present interestingly a paper that contains 90 or even 40 per cent mathematics to a cross section of the aeronautical profession is beyond the ability of most lecturers. Also, in 30 or 40 min., the members of the audience, even the ablest ones, cannot follow the derivation of mathematical concepts that took the authors months to develop. To appreciate the value of such papers one has to relax, pad and pencil handy, and follow the author step by step. What is the solution? Bar mathematical papers? No, a thousand times no! Present them by title? Read the abstract only? Make two versions—a spoken one and one for publication? Better brains than those possessed by your reporter must decide this, but everybody will probably admit that such a problem exists.

Some papers were excellently presented; some sounded as if the authors had kept them in mothballs, dusted them off for the meeting, and read them with the thought: "Let's have it over with." The authors should remember that 10 per cent of the papers submitted are chosen for presentation; hence, the lucky ones should feel this honor and privilege and should do it justice by rehearsing, rehearsing, and rehearsing again. Don't read your paper. Memorize the salient points; the rest will come automatically. Follow the precept of the famous negro preacher who, when asked the secret of his success as an orator said: "Ah reads maself full, ah thinks maself straight, ah prays maself hot—then ah lets go."

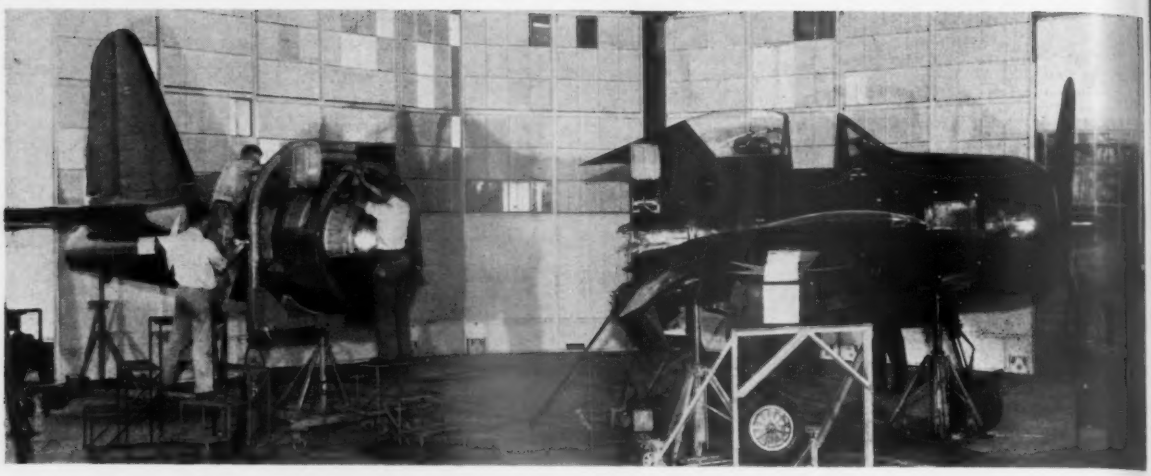
How well some of the members recall the Second International Aeronautical Conference when, in the matter of presentation, our British friends outperformed us ten to one. The N.A.C.A. staff has proved over and over again that a rehearsed, *spoken* version of a paper thrills the audience, while the verbatim reading of a paper would invariably put the hearers to sleep, if the hotel cooperated and provided comfortable chairs.

One more comment—your slides. Follow the Institute's instructions in preparing them. What good is a slide that nobody can read? There were a number of them prepared by rank amateurs. It costs only $0.95 for a good professional slide. It's worth it! Signing off.

It was a good meeting, it was fun to be your reporter; God willing, I'll see you in 1951.

As ever yours,
"Steve"

P.S. (Commercial) Reprints are still available. Write the Institute for your copy, but hurry, the supply is limited.



JET INSTALLATION DESIGN PROBLEMS

*Symposium by a Panel of Experts**

Mr. Robinson: During similar meetings of the Institute over the past few years, we have had papers presenting the relative advantages of the reciprocating engine, the turbojet engine, the turbojet, and the turboprop; papers covering centrifugal and axial compressors, annular combustion chambers, and fixed- and variable-area nozzles; and papers covering the performance advantages of specific designs of machinery. When the turbojet engine was first introduced, it was considered to be an extremely simple mechanism—easy to install because of its simplicity of mounting, its moderate air and fuel requirements, and the absence of the propeller and perfect principally because it seemed to be more complex than the then current reciprocating engine. Our ideas have changed regarding all of this, not because of any changes in the basic engine from the standpoint of its design and construction but because of the rapid growth inside the engine and the performance possibilities of the airplane resulting therefrom. Engine sizes have increased from the 1,300 lbs. thrust of the original General Electric IA to engines of more than 6,000 lbs. thrust, such as the current Pratt & Whitney J-48. Aircraft speeds in excess of the speed of sound are subject to current newspaper comments, with talk of flying passengers at stratospheric altitudes. All of these performance demands have their effect on the engine installation, together with the active demands of the service for armament, navigational, and detection apparatus.

Presented at the Eighteenth Annual Meeting, I.A.S., New York, January 23–26, 1950.

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Chairman

S. T. Robinson, Engineer, Sanderson & Porter.

Speakers' Panel

Aircraft Designers' Point of View

John Karanik, Chief Power Plant Installations Engineer, Grumman Aircraft Engineering Corporation.

John S. McCarthy, Power Plant Technical Engineer, McDonnell Aircraft Corporation.

Engine Manufacturers' Point of View

M. C. Benedict, Installation Section Engineer, Aviation Gas Turbine Division, Westinghouse Electric Corporation.

Dimitrius Gerdan, Chief Engine Engineer, Allison Division, General Motors Corporation.

R. E. Small, Manager, Commercial Engineering Section, Aircraft Gas Turbine Division, General Electric Corporation.

Charles S. Jewett, Project Engineer, Wright Aeronautical Corporation Division, Curtiss-Wright Corporation.

Willard Gorton, Development Engineer, Pratt & Whitney Division, United Aircraft Corporation.

Discussers

John H. Collins, Chief, Engine Performance & Materials Division, Lewis Flight Propulsion Laboratory, N.A.C.A.

Gaylord W. Newton, Chief, Power Plant Unit, Boeing Airplane Company.

Raymond B. Maloy, Chief, Engineering Flight Test Division, C.A.A.

Lt. J. Lynn Helms, U.S.M.C., Jet Training Unit One, N.A.A.S., Whiting, Milton, Fla.

There is little point in comparing the magnitude of the air and fuel flows of the reciprocating engine with those of the modern jet engine, since we are dealing in hundreds of pounds of airflow per second and thousands instead of hundreds of gallons per hour in fuel flow. Is it any wonder that the modern single-engined fighter is comparable in size to the DC-2 instead of the airplane of a few thousand pounds gross of that same period? This morning we are going to hear something of these problems: first, from the aircraft industry stating its case and then from the engine manufacturer. You will be given the opportunity of asking questions, and a special panel of experts will, I'm sure, provide you with satisfactory answers.

Our first speaker, John Karanik, will present briefly the basic problems in turbojet installation restricted to discussion of fuselage installations. Mr. Karanik is well qualified to discuss this problem, having led the group responsible for the installation of the Pratt & Whitney J-42 and Allison J-33 in the Grumman Panther, or F9F, one of the Navy's first-line fighters. Mr. Karanik is a graduate of the Daniel Guggenheim School of Aeronautics, New York University, class of 1936, Bachelor of Science and Mechanical Engineering, and Professional Engineer licensed by the State of New York and has been employed by the Grumman Aircraft Engineering Corporation since 1939 in the capacity of Power Plant Engineer.

Mr. Karanik: This presentation of jet engine installation problems is restricted to fuselage installations only, since time does not permit an adequate discussion of the others. Jet power pods that are suspended from the wings or the fuselage on certain types of aircraft are regarded with envy by the power-plant engineer who must devote his efforts to a submerged fuselage configuration.

Installation problems begin with the initial layout of a new airplane design. Final difficulties can be minimized by proper consideration, during this phase, of the problems involved. The choice of an engine location with a single inlet ducting scheme usually precludes the possibility of a simple and trouble-free airplane fuel system. Since large quantities of fuel must be carried, the location of the fuel tankage in the fuselage will make it necessary either to split the engine inlet ducting scheme or to scatter the airplane fuel tankage, thus aggravating balance problems due to fuel usage. The presence of the radar scanner in the nose of the fuselage will likewise influence the decision with regard to a split engine intake ducting arrangement.

For a minimum engine thrust loss, the exhaust gases should be disposed of with the minimum tailpipe length. Here again, the initial layout of the airplane—with its tail configuration and, in the case of Naval aircraft, the arresting hook requirement—will determine the magnitude of the fuselage cooling problem, the installed thrust loss problem, and the flexible tailpipe problem.

Engine accessibility is generally far from ideal, since it is impractical to provide all the access openings that a maintenance unit may desire. A quick engine removal scheme is therefore necessary to provide complete access for servicing the engine.

In the case of a single-engine fuselage installation, it has usually not been possible to utilize the smaller frontal area per unit thrust of the axial engine, since other factors such as fuel capacity have determined the fuselage size. The shorter length of the centrifugal unit permits the fuel to be located more efficiently.

In spite of all the installation problems, it has been found profitable to provide for a substitute engine installation for a particular airplane. It is really amazing to see the progress of engine development between engine manufacturers when a competitive power plant is proposed.

The air intake system for the engine must aim at bringing the air to the face of the engine with the least possible loss of energy. The final arrangement of the ducting scheme will try to minimize the external flow disturbance to the airplane, will seek to minimize internal flow losses, and will endeavor to achieve a satisfactory compromise with the requirements of other items, such as armament, fuel stowage, etc., to produce a desirable general arrangement.

Available American engines fall into two groups: axial-flow compressors and double-faced centrifugal compressors. The choice of engine has a significant effect on the ducting problem, inasmuch as the double-faced centrifugal compressor imposes several inherent penalties: (1) The inlet duct must be an efficient diffuser and therefore requires more space, (2) the plenum chamber involves certain dumping losses, and (3) the test stand corrected performance can never be achieved practically in the airplane. To date, the direct ramming type of inlet has been generally adopted, since the ram recovery has proved acceptable over a wide range of speeds. In future designs, the flush inlet may be refined to the point where better ram recoveries at the higher speeds will be available.

Since any ducting system should consider the inevitable growth of the airplane, and correspondingly of the power plant, allowances should be made for increase in airflow without loss of intake efficiency.

For the best possible ram recovery, the entrance of the ducting must, of course, be located at a point in the aircraft where the maximum pressure is to be expected. These points are at the nose of the fuselage and at the leading edge of the wing, or they may be created by the introduction of scoops. The nose duct is objectionable, since it occupies space that could be used more efficiently for the radar scanner, personnel, and armament. This type of inlet, while being ideal at the entrance for pressure recovery, is usually long and sometimes tortuous. The effective ram recovery at the engine may therefore be not better than a shorter, more direct split ducting scheme where side inlets are employed. The side inlet ducting arrangement

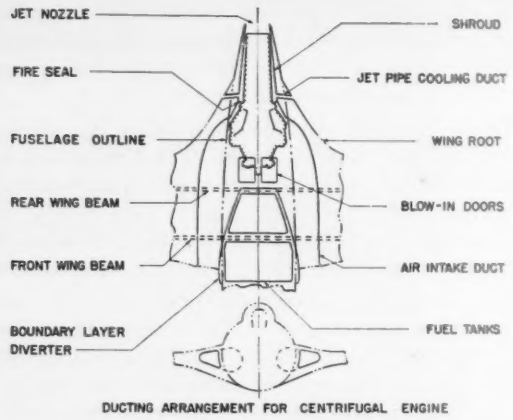


FIG. 1.

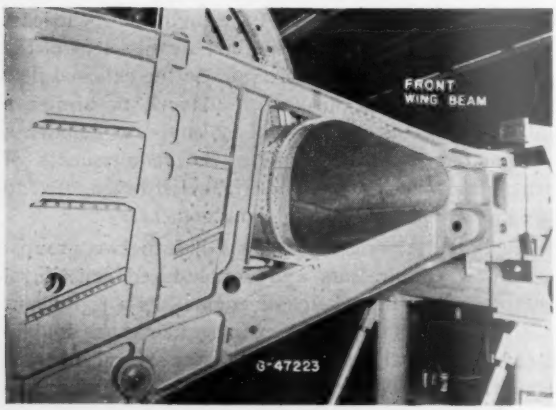


FIG. 2.

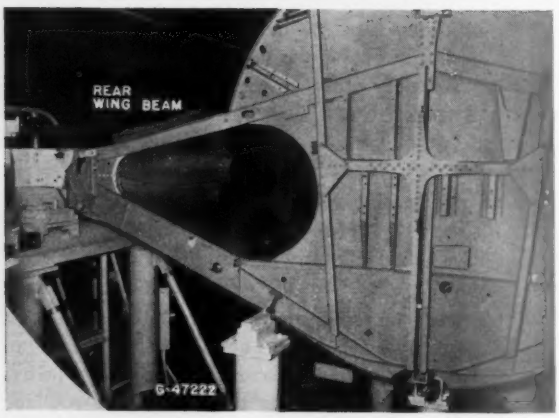


FIG. 3.

must beware of the fuselage boundary layer, which reduces the working area of the duct and may cause serious separation losses. Under such circumstances, a means of by-passing this low-energy air must be used. The complexity of the boundary-layer control scheme will be a function of the thickness of the boundary layer and the effect of the boundary layer on the ducting.

To avoid a complex control scheme, side entry ducts should be located well forward on the fuselage. The wing inlet type arrangement presents a compromise side ducting arrangement. While it reduces the boundary-layer problem insofar as the depth of the ducting is shallower at the side of the fuselage, it introduces a thick wing root section and structural complications.

Fig. 1 depicts a typical twin ducting arrangement for a centrifugal engine. In this case, the entrance area located in the wing is clear of the fuselage. The essentially straight portion of the ducting attempts to convert the greater part of the flight dynamic head into static pressure in the optimum length. At the end of the ducting most of the remainder of the dynamic pressure is lost in dumping and turning into the plenum chamber. The blow-in doors illustrated are designed to permit more airflow into the engine during ground and take-off operation. The duct pierces the main beam at this point.

Figs. 2 and 3 show the structural complexity that was involved in this wing inlet type of system. The size of the hole with respect to the remaining structure illustrates typically the necessity of close coordination between the aerodynamic and structural design of the airplane, all resulting from power-plant requirements. It would appear that it took the power-plant problem to get the structures and aerodynamic people together. In this instance the usual objections to a thick wing root section have been minimized by an internal duct flow that effectively reduces the wing thickness.

The importance of a good inlet system may be illustrated by the climb performance of an airplane. The effect of a change of ram recovery will vary with altitude and with the different types of engines. The centrifugal type engine with its maximum expansion type of ducting will inherently have higher ram losses. On one fighter type of aircraft, a 10 per cent loss in duct efficiency reduced the sea-level rate of climb by 7 per cent. For the same 10 per cent loss in duct efficiency, the time to climb to 40,000 ft. was increased by 15 per cent.

After deciding how to get the air into the engine, the power-plant engineer is faced with the "hot" problem of how to get this same air out. The exhaust system presents that means. The difficulties involved in this system may be divided into the aircraft cooling, the thrust loss, and the flexible tailpipe.

With tailpipe gas temperatures of 1,200°–1,300°F. even without afterburning and with aluminum-alloy structural temperature limitation approximately 250°F., it becomes necessary to prevent the transfer of tailpipe heat to the aircraft structure. In some cases, this is accomplished by introducing air through a stainless-steel shroud surrounding the combustion chamber and tailpipe sections. Looking again at Fig. 1, you will find this arrangement. The shrouding serves as an insulating barrier and is also an excellent fire-protecting wall. The air required for cooling can

either be bled from the engine air inlet duct or may be obtained by separate external ducting. In Fig. 1 an independent external ducting system for introducing the cooling air is employed. Originally, the cooling air was bled from the plenum chamber, but ejector action sufficient to cool on the ground was found to be excessive in flight and produced a large cooling air drag adversely affecting the performance of the airplane. Attempts to reduce the cooling drag in flight by using a less effective ejector resulted in reverse flow during ground operation. The application of ejector pump action for tailpipe cooling when a variable area nozzle is employed is even more difficult. The problem of achieving minimum drag and adequate cooling under all operating conditions, for a nozzle that varies in area by 50 per cent, is not easily solved.

Insulation blankets on other installations have given satisfactory aircraft temperature protection. However, these are generally heavier than a shrouding arrangement.

The cooling problem becomes more acute in an installation with an afterburner, since the temperatures may approach three times the normal tailpipe temperatures. In this case, both the stainless-steel shrouding and an insulating blanket may be required for structural protection. It appears that the engine manufacturers would have much to offer in a scheme that provides integral cooling of the tailpipe. While integral cooling might penalize the engine itself, it could well improve the airplane engine combination. Such a scheme would be analogous to the development of tightly baffled air-cooled cylinders on piston engines.

It is desirable to make the jet tailpipe as short as possible to avoid tailpipe weight and tailpipe thrust losses. However, for fuselage installations, the airplane tail location and, in the case of naval aircraft, the arresting hook requirement make it difficult to use the shortest tailpipe. For an installation where the tail configuration extends over and beyond the jet nozzle, clearance must be provided for the jet wake. If this clearance is determined on the basis of sea-level requirements, it is probable that the wake will impinge on the aircraft, with a resultant loss in thrust when the engine operates at altitude where pressure ratios are higher and where expansion from the nozzle is more abrupt. On some engines it has been found that tailpipe temperatures have increased with altitude. Thrust will be penalized for low-altitude operation if the fixed nozzle is designed so that maximum tailpipe temperatures will not be exceeded. It appears that some device, certainly less complicated than the usual variable area nozzle, is needed to change the nozzle area slightly for the altitude performance. Such a device could also serve as a means of tailoring each production engine to its maximum operating temperature.

Even with rigid mounts and fuselages and short tailpipes, flexible joints have been required to accommodate aircraft deflections during flight or landing. To date, the service life of some flexible tailpipes has not been entirely satisfactory. Failures have been experienced on a flexible bellows on one engine, whereas the identical design has been satisfactory for a substitute engine in the same airplane. This indicates that all is not known about the conditions controlling tailpipe design.

FIG. 4.

FIG. 5.

Access to the engine, which may well be in the heart of the airplane, becomes extremely difficult. To provide for all the openings necessary to service the engine completely without its removal would make the fuselage aerodynamically dirty and structurally heavier. Access provisions are usually limited therefore to those items that require most frequent inspection and maintenance. Access to the nose accessory section is especially difficult in the case of axial-flow engines because of the inlet ducting surrounding this area. To solve this difficulty a section of the ducting must be made removable.

The centrifugal-type engine presents a less troublesome problem. The blow-in doors provide an excellent means of general accessibility for adjustment and maintenance of equipment on and around the engine. Fig. 4 shows a member of the ground crew of a fighter aircraft gaining access through these doors. These doors are located over the accessories and are quickly removable if required. Fig. 5 shows another method of

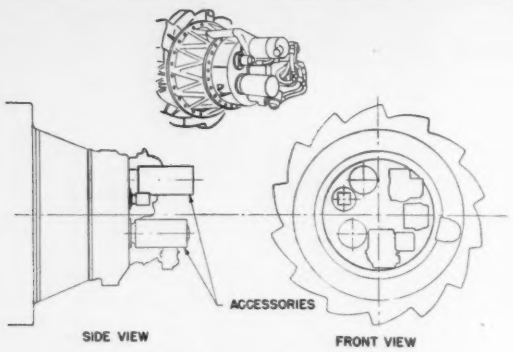


FIG. 6. Original engine accessory section.

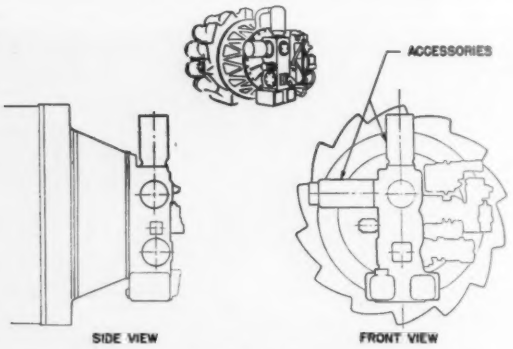


FIG. 7. Revised engine accessory section.

gaining access to the engine. Here a member of the crew has crawled into the air intake duct. While this scheme was not originally proposed for service use, it has been accepted as standard procedure. The Marines report they use this method for governor adjustment with the engine turning up slowly, but it is not recommended practice. Entrance has also been made via the tailpipe for igniter operation inspection. However, after one inspector was blown out of the tailpipe, another inspection procedure was devised.

Fig. 6 illustrates changes made in the accessory arrangement to improve accessibility. Accessories located on the front of the engine make accessibility extremely difficult and, incidentally, increase the engine overall length. Fig. 7 shows a redesigned accessory gear case for the same engine locating the accessories radially. This new location permits better access to the accessories and reduces the engine overall length.

Since it is impractical to provide complete access, a quick and easy engine-removal scheme must be employed. The methods generally used to date are based on either removing the engine from the top or bottom of the fuselage or removing the tail section of the airplane and extracting the engine from the forward fuselage section. Fig. 8 shows this latter method. The engine and tailpipe are cantilevered from the forward fuselage section. Note the small clearance between the engine and structure. Whenever this method of extracting is used, whether the engine is centrifugal or axial, the clearance tends to be small. On axial-flow engines, with their accessories mounted outside the normal contour, extraction by this method necessitates a larger than minimum hole.

It appears that the most troublesome feature on present-day jet engines is the engine fuel system. The poor performance of these systems indicates the need for a more simple scheme. While the reliability of the fuel system is not an installation problem, the type of system does "affect" the installation of controls for its management. Some systems provide so many alternate procedures or emergency routines that the pilot is likely to become hopelessly confused in an emergency. With the introduction of further design requirements for the fuel system by the services, the added complexity has resulted in added unreliability. This has been experienced with a system designed for a particular engine to prevent the pilot from causing an altitude blowout. Actually, more altitude blowouts have occurred with the use of this system than with the use of a previous system not having that requirement. It would be helpful if the services could coordinate the operation of fuel systems with engines likely to become alternate power plants in the same airplane.

In summary, the problem of fuselage installations of jet engines may be avoided or lessened by proper consideration during the initial layouts of the design. The types of intake ducts have been discussed and the importance of a good inlet system indicated. Tailpipe and exhaust nozzle cooling problems present a challenge to engine manufacturers to develop integral engine-cooling schemes. Since complete access cannot be provided for the engine, a quick and easy engine-removal scheme is suggested. A need for review of the engine fuel system is indicated by the poor performance of present-day systems.

Mr. Robinson: John, that was a good presentation of the basic problems, but under this shiny skin is a maze of systems and accessories that are essential to keep the airplane and engine in operation. We're going to hear about this phase of the installation problem from John McCarthy. Mr. McCarthy was gradu-

FIG. 8.

ated from Purdue University, B.S. in Mechanical Engineering in 1942. He was employed by the Wright Aeronautical Corporation as a Test Engineer, had a number of years with the N.A.C.A. and also the science laboratory in Cleveland, and for the last 3 years has been at McDonnell Aircraft as Power Plant Engineer. His background and experience, I think, make him well qualified to treat this problem of engine accessories.

Mr. McCarthy: Mr. Karanik has ably summarized for us a good part of the problem of jet engine installation—that of the basic engine itself. I am glad to have the opportunity of sketching out the rest of the overall problem—that of systems and accessories—particularly because representatives of our leading jet engine manufacturers will have a chance to present their side of the picture, too. It seems all too seldom that we can lift ourselves out of the detail of the jet engine business to take the long perspective view of where we've been and where we're going.

I have divided the field of systems and accessories into three major parts: Cooling, Auxiliary Power, and Fuel Systems. We will then momentarily discuss oil systems and starting problems. Most of what I have to say will apply primarily to turbojet engines in fighter aircraft, but many points will also apply to turboprop engines and to larger aircraft. I will try to summarize past and current practice in each field and to indicate the problems that seem to be looming up on the horizon.

Most of the cooling of jet engines is done internally, much as reciprocating engines are cooled at take-off power. As Mr. Karanik pointed out, the internal parts of the engine are limited to temperatures of the order of 1,500° to 1,700°F. Because fuel-burning in the area of the fuel nozzles must take place at near chemically correct fuel-air ratios, combustion temperatures approach 3,000° to 4,000°F., and large quantities of cooling air must be immediately available to be mixed with the combustion gases. In practice, this cooling air is pumped through the compressor with the combustion air. Of every 4 lbs. of air entering an engine, only 1 lb. combines with fuel in the combustion chamber. Of course, if another pound could be used for combustion, higher temperatures, thrusts, and efficiencies would be obtained. Actually, in afterburner engines, the extra pound is burned downstream of the engine, and, although the efficiency is not raised, because of the low afterburner combustion pressure, both thrust and gas temperature are raised, the latter to values over 3,000°F.

Engine shell temperatures in still air are almost equal to the internal gas temperatures, ranging from 400°F. at the compressor outlet to, perhaps, 1,600°F. at the turbine housing. Although most nonafterburner engines may be operated safely in still air at these temperatures, external cooling is vital to afterburners and must be supplied at all times during afterburning to prevent destruction of the burner shell and to protect any nearby air-frame structure.

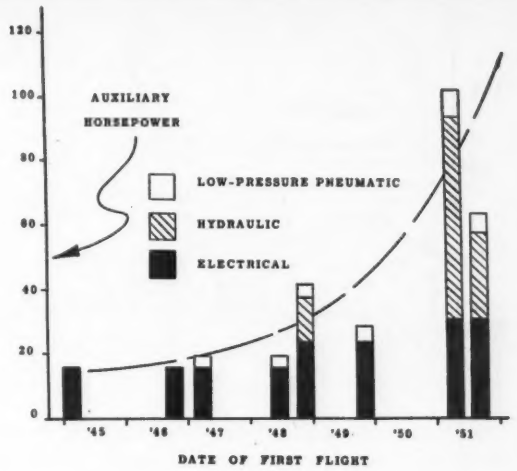


FIG. 1.

The most difficult current problem in cooling jet engine installations is to get just the right amount of cooling airflow, both on the ground and in flight. Too much creates unnecessary airplane drag—too little can cause engine or air-frame overheating troubles. Today, the entire cooling arrangement is designed almost wholly by rule of thumb and plain horse sense. For example, the cooling shrouding described by Mr. Karanik depends to some extent upon ejector action for its effectiveness. There is no basic data available on the performance of ejectors with primary nozzles which are other than perfectly round (such as the almost universal clamshell afterburner nozzle), or concentric ejectors, or ejectors having any type of exit fairing beyond the ejector throat. This is a basic obstacle to scientific engine cooling.

Another obstacle is the general lack of information from the engine manufacturers. It is generally conceded that the engine manufacturer should supply the afterburner shroud and ejector, and this is usually done. However, all too often, little or no ejector performance data are made available for pressure differentials other than 1 to 1 or for operating conditions other than sea-level static. In addition, heat-transfer and heat-rejection information is usually not available; as a rule, only maximum operating temperatures are supplied.

In the days of reciprocating engines, the engine manufacturers became the prime authorities on engine cooling. However, in the turbojet era, no such trend has developed, and the great bulk of the problem has been tossed to the air-frame manufacturers. Fortunately, we have made good guesses so far, usually on the side of overcooling. However, as the art becomes more and more refined, it will again be up to the engine manufacturers to take the initiative in the accumulation, correlation, and dissemination of reliable cooling data for their engines.

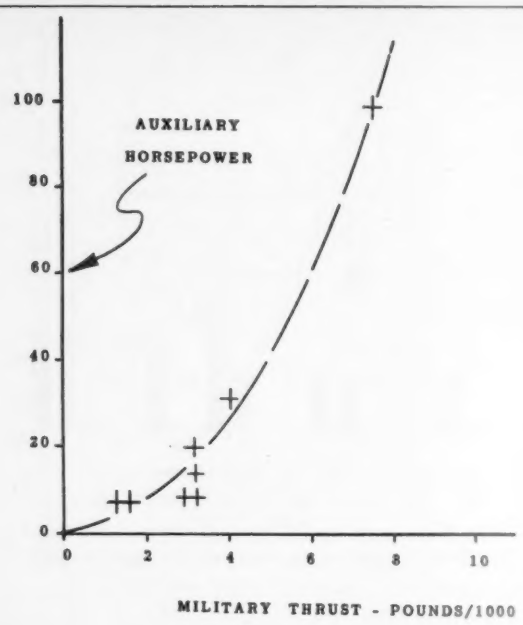


FIG. 2.

The auxiliary power demands upon the engine have been increasing at a startling rate during recent years, as shown in Fig. 1. The vertical bars represent the total maximum horsepower required from the engines in six-jet fighter aircraft built by McDonnell since 1945 and two planned for the near future. The solid portion represents electrical power; the shaded portion, hydraulic. These amounts are taken from the engine as shaft horsepower. The clear portion represents that power taken off in the form of compressor bleed air for air conditioning the cabin and electrical, camera, and armament compartments and for wing anti-icing. The powers represented constitute only about 1 per cent of the engine power at low altitude, but, since engine power decreases with altitude faster than the aircraft demands, the percentage becomes much greater at heights of 40,000 to 65,000 ft.

As engines become larger, the auxiliary power demands made upon them tend to increase at an accelerating rate, as shown in Fig. 2 in which the powers taken from the engines in Fig. 1 are plotted against engine size in terms of military thrust, nonafterburning.

Of course, it is most desirable to mount aircraft accessories directly on the engine, and this has been accomplished in the aircraft illustrated in the previous figure. However, this is becoming a more and more difficult problem because of the necessity of maintaining small engine frontal area. Thus, it is inevitable that space on the engine for mounting aircraft accessories is becoming more and more scarce, and other approaches to the auxiliary problem must be examined.

The problem is, first, to take power from the engine—or perhaps an auxiliary power plant—and then distribute it to the points in the aircraft where it is needed with the lowest weight and smallest size. Current practice for aircraft in service is shown schematically in Fig. 3. Although most auxiliary power is currently taken from the engine in mechanical form and converted into electrical or hydraulic power for distribution, all four distribution methods have advantages. None is universally superior; each is adapted particularly well to certain applications.

Electrical energy is perhaps the easiest to distribute and to control and is required to some extent in every aircraft for lights and radio. Some of the aircraft in Fig. 1 use it for nearly every auxiliary power requirement. Its main disadvantage is that, where large, quick-acting forces are required, the size and weight of the necessary actuators become excessively great, so that electricity is best adapted to applications requiring fairly low power.

Hydraulic power, on the other hand, has been used primarily for applications requiring quick expenditures of large amounts of energy, such as actuation of bomb-bay doors, landing gears, and dive brakes. It is used almost exclusively in control boost systems. Where little space is available, as in modern fighters, a 3,000-lb.-per-sq.in. system is indicated to minimize the size of the actuator cylinders.

Probably the most widespread application of low-pressure pneumatic power has been the use of engine compressor bleed air for pressurization and air conditioning. On the other hand, high-pressure air is taken from either electrically or engine-driven reciprocating-type air pumps; the pneumatic energy is stored in accumulators for use in gun charging and various emergency actuations.

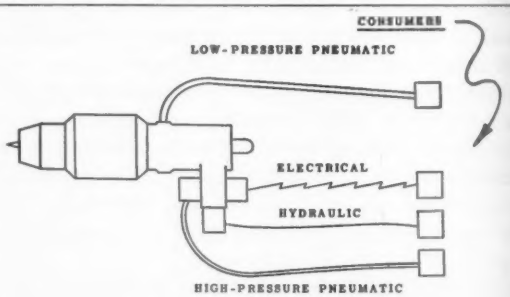


FIG. 3.

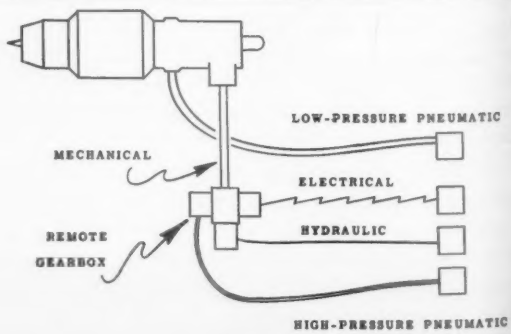


FIG. 4.

As engine compartments become more and more cluttered, it will be desirable to locate auxiliary power equipment in other parts of the airplane for accessibility and to make it easier to maintain small frontal area for the overall power-plant installation. Fig. 4 shows one much-discussed method—that of using mechanical extension shafts. This arrangement is not used in current aircraft, but it is being seriously considered for several now in the design stage.

Another possibility is pneumatic power extraction, which should undergo considerable development in the next few years. Fig. 5 illustrates one arrangement that seems promising, particularly for large aircraft. Compressor discharge air is bled off one or more engines and passed through a small combustion chamber into a gas turbine having a variable-area exhaust nozzle. The turbine, which may easily be located some distance from the engine, is geared to electrical generators, hydraulic pumps, or pneumatic high-pressure pumps and can be maintained at constant speed by controlling the exit nozzle area and the combustion temperature. This system will therefore be particularly adaptable to driving large alternators.

There are three things the engine manufacturers should do to help the air-frame manufacturer with the auxiliary power problem:

(1) He should provide a variety of power take-off pads to accommodate mechanical extension shafts.

(2) He should make provisions for efficient bleeding of up to 10 per cent of the engine airflow through any one of several bleed bosses on the compressor housing. The bleeding of air for aircraft uses should be considered from the earliest stages of engine design.

(3) He should mount all engine components—such as fuel controls, fuel pumps, oil pumps, filters and tachometers—directly on the engine as compactly as possible with closely grouped adjustment points while still maintaining minimum frontal area.

In addition, he should provide alternate locations for as many of them as possible, or he should design the entire engine for permanent mounting in the aircraft in a variety of positions, since for aircraft layout purposes it is frequently desirable to alter the location of engine accessories. Engines that are not flexible in accessory arrangement will be severely limited as to numbers of possible applications. In our studies of one airplane, for example, we found it necessary to eliminate two otherwise excellent engines from serious consideration because of inflexibility of engine accessory arrangement. Engine manufacturers must realize that the success or failure of an engine (and frequently of the manufacturer himself) depends to a large extent on the adaptability of his engine at the time aircraft proposals are first made to the Armed Services.

Aircraft fuel-system design is almost becoming a science in itself. Even as recently as 3 years ago, fuel-system design for fighter aircraft was relatively straightforward. It was simply necessary to provide self-sealing tanks with electrically driven booster

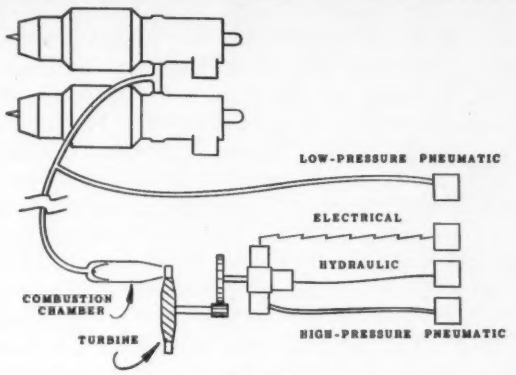


FIG. 5.

pumps and some means for tank selection—either manual or automatic. Vent lines were arranged to prevent fuel siphoning in flight maneuvers. They were about $1^1/_2$ in. in diameter, large enough to prevent the build-up of excessive expanding pressures due to fuel boiling in fast climbs and adequate during fast descents to prevent collapsing pressures. But the catch is that in those days a fast rate of climb was perhaps 6,000 ft. per min. at sea level, and a fast descent was of the order to 40,000 ft. per min. However, fighters for which fuel systems are now being designed will be capable of rates of climb well over 20,000 ft. per min. and descents of 75,000 ft. per min.

The venting problem is further complicated because of fuel boil-off in those aircraft using high-volatility fuels, such as gasoline, as opposed to JP-1 or kerosene. A present-day fighter taking off with 1,000 gal. of gasoline at 80°F. and climbing to 40,000 ft. will lose roughly 60 gal. of fuel because of pure vaporization, beginning at 27,000 ft. In addition, some liquid fuel may be bubbled overboard because of the violence of the boiling process, depending on tank and vent configuration. In current fighters, these losses are accepted as more or less inevitable; however, for the new designs in which fuel capacity is more critical, such losses will be intolerable. Although the new aircraft will use JP-3, which is slightly less volatile than gasoline, the boil-off problem will still be critical because flight ceilings will be higher—in the neighborhood of 60,000 ft.

There are several possible solutions to the problem—all of them unattractive. First, the tanks may be pressurized to keep them at a safe equivalent altitude, but this involves internal pressures of the order of 6 lbs. per sq.in. at 60,000 ft., which requires extremely heavy tank-supporting structure, particularly in the case of odd shapes, such as horseshoe tanks that fit around the engine or large flat tanks for thin wing panels. In addition, it is impossible for tanks to self-seal against gunfire punctures at pressures much over 2 lbs. per sq.in. The obvious thing is then to reduce tank pressure to 2 lbs. per sq.in. just before entering combat, but at 60,000 ft. this is equivalent to a tank altitude of 40,000 ft., which, as we have seen, offers little protection against vaporization.

A second alternative might be to refrigerate the fuel to 50°F. In combination with pressurization to 2 lbs. per sq.in. this will prevent vapor loss to altitudes as high as 60,000 ft. For flight up to 50,000 ft., the fuel must only be cooled down to about 60°F. In spite of the complications in ground equipment, this may actually be the most attractive solution. We have found that fuel stored underground stabilizes at about 60°F. year round and that fuel stored in small tank trucks in August sunlight takes 2 days to reach 85°F.

Various proposals concerning gadgetry to be carried aboard the airplane for condensing or trapping fuel bubbles and vapor or for refrigerating the fuel have usually been found to be nearly as expensive in weight and drag as the fuel saved.

Another serious fuel system complication lies in the fact that fuel must be available to the engine under 10 to 50 lbs. per sq.in. pressure for a large variety of aircraft attitudes. This usually means assorted baffles, check valves, solenoid switches, and some duplication of pumping equipment. Even with the best systems, however, there are always some flight conditions where the boost pumps will be uncovered and fuel pressure to the engine will drop to, or slightly below, tank pressure. Unfortunately, these are often just the maneuvers where the pilot needs his engines the most. The engine manufacturers, therefore, should design their engines accordingly. The engine of the future should continue to operate—even if at reduced engine speed—on the fuel in the aircraft fuel lines at pressures near ambient up to the fuel boiling altitude. When the fuel in the lines is exhausted, the fuel pump should be capable of running dry for periods up to 30 sec., and the fuel system should reprime itself immediately when fuel pressure is resupplied.

In view of the high rates of climb to be realized in the fighter aircraft of the near future, boost pump manufacturers should also re-examine their performance criteria. Current boost pumps are guaranteed for low rates of climb—usually 7,500 ft. per min., although most can do better, particularly in pressurized tanks. Rather than 7,500 ft. per min., a more suitable short-range target might be a rate of climb of 25,000 ft. per min. at sea level, tapering linearly with altitude to zero at 60,000 ft., with tank pressure equal to 2 lbs. per sq.in. above 25,000 ft. A fuel temperature of 85°F. would be more realistic than the current test value of 100° or 110°F.

The oil systems of some of the earliest jet engines were noncirculating—that is, oil was pumped from the aircraft tank and sprayed on the engine bearings at a slow rate and consumed. Three or 4 years ago, a typical circulating oil system was a simple tank, with an outlet in the bottom, an inlet at the top, and some sort of baffle arrangement for foam suppression. The only major change over reciprocating practice was that some tanks incorporated pressure relief valves in the vent lines and were pressurized to about 4 lbs. per sq.in. by the relatively large amount of air returned to the tank with the scavenge oil. But tanks of this type provided oil only in level flight and in shallow climbs and dives.

Recently, however, it has become necessary to provide fighter engines with oil during a wider variety of flight maneuvers, including inverted flight for periods up to 25 sec. This presented a difficult design problem, because it was not only necessary to have the oil exit covered with oil in these maneuvers but also necessary to keep the vent line uncovered and to suppress foaming at the same time. Tanks that accomplish these objectives are installed in several fighters now flying, including the Navy's Phantom and Banshee, and the Air Force XF-88.

It soon became evident, however, that it would be desirable to have the oil reservoir made an integral part of the engine, and this has been done in some of the newer large engines now under development. This happily relieves the air-frame manufacturer of the oil tank responsibility, but, since the engine-mounted oil tanks do not provide oil supply in inverted flight, the engine—and, consequently, the aircraft—may be flown inverted only as long as the engine bearings will operate without oil. Clearly, the engine manufacturers must improve this situation for fighter engines.

There are two phases of the engine starting problem: first, supplying the necessary power without compromises in aircraft design; second, establishing a suitable universal starting technique. As engines become larger, proportionally greater power is needed for starting, as shown in Fig. 6. Electrical starting has been satisfactory for the small engines, but, as larger engines with higher compression ratios have come along, electrical starters have become prohibitively large. This has led to the development of smaller lighter types. Perhaps the best known is the pneumatic, or air turbine, unit, which is indeed compact and light. Its big disadvantage—for fighter aircraft primarily—is that its companion high-pressure air source is a small turbine-driven compressor unit that weighs some 150 lbs. and which takes up about 6 cu. ft. of aircraft space. Even so, pneumatic power is probably the best current answer to the starting problem.

However, at least two better ideas seem feasible. One is cartridge starting, which uses small slow-burning solid rocket charges, and another is that in which steam released by decomposition of hydrogen peroxide is utilized to drive a small steam turbine geared to the engine. The former is apparently a development of cartridge starting of reciprocating engines, and the latter is, of course, almost identical to the propellant pump drive developed for rocket engines by the Germans during the war. It is hoped that the engine manufacturers will be able to adapt their engines to the use of these new developments if and when they become available.

Beyond the problem of obtaining starting power is the problem of starting technique. Not too long ago, each airplane-engine combination had its own individual starting procedure—usually strictly manual,

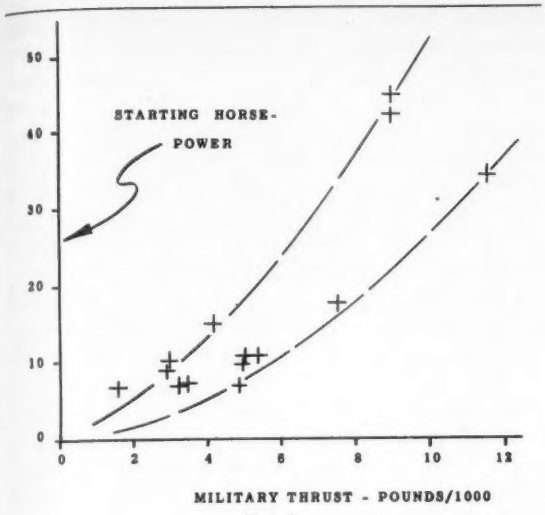


FIG. 6.

requiring a well-trained pilot to throw switches and move levers in the proper sequence. As time went on, it became clear that some standardization would be necessary—preferably on some more or less automatic procedure in which the pilot had perhaps one switch and one lever to move in simple sequence. The Armed Services began to ask the air-frame manufacturers to incorporate such throttle quadrants in their cockpits. Many good attempts were made, but none was particularly successful because starting characteristics varied too much from one engine model to another and because many engine control systems were not intended to be adapted to automatic starting. Thus, the need has arisen for standardization of engine starting systems. Such a standard is far from an impossibility, and it may be desirable for engine manufacturers—especially those dealing with both services—to meet and establish their own recommended standard. If such a standard could be presented to both services, it might avert the confusion involved when several separate standards are established simultaneously.

In summary, I believe it can be said that the engine manufacturers have come a long way in a new and fast changing industry but that greater problems and responsibilities lie ahead.

Mr. Robinson: I think the aircraft representatives have presented an excellent picture of the problem here.

Mr. Benedict: The aircraft company's problems, speaking as an engine manufacturer, are our problems, and we have tried continuously to meet those problems in the best way we know how. That battle is not yet licked, and it never will be, because the problems that we tackle are definitely intangible. In trying to look where we are going, it is my general impression that we are being pushed and that the conditions we are designing for are definitely not a set of conditions of our own choice but ones in which we were forced to concentrate all our endeavor to give our Armed Services equipment that they need—for instance, the altitude interception problem. Until $1^1/_2$ years ago there was definitely no squawk whatsoever about our engines having guaranteed altitude performance in the neighborhood of 35,000 and 40,000 ft. Recently, since the Geiger counters started to click around the world, we are pikers if we don't guarantee at least 60,000 ft. Things like that just can't be handled with a snap of a finger, and the problems that are coming up now are beginning to reflect the effect of major tactical problems that are being forced both upon the aircraft people and the engine people to do the job that is required of us—to supply the defense of our country. That's a little bit abstract from the answer to some of these timely problems that have been put to us, and I want to comment just briefly on several of them.

In respect to afterburner cooling, the aircraft manufacturers have presented a perfectly truthful and honest evaluation of our position on cooling at the back end of the airplane and thrust loss involved. Whoever started the stampede for clamshell nozzles should be shot, because the clamshell nozzle is not an ideal nozzle, as we have found out for ourselves. It has several aspects that are good, but it has many others that are bad. Because of the fact that it has a central hinge point, in which most of the loadings on a nozzle are radial from the hinge points, it would appear that you would end up with a light actuating load and that, if the nozzle efficiency is reasonable, you should have a good arrangement—simple mechanically, light, structurally sound, and cheap to produce.

However, along with it comes such problems as seal leakage and such problems as having a tail end of an airplane that is cut off square, like the back end of a book. The aerodynamics department in the airplane companies will not stand for such a thing. They strive mightily to pick up fractions of miles per hour by clean design and sweating blood over minute external detail of the airplane, so why should they throw away 2 or 3 per cent on the back end of the airplane? We think that the ultimate solution will probably be a combination of internally and externally cooled rear ends, hot afterburner, and tailpipe.

In the past, every cooling problem we have come up against has been licked with variable control, starting back with the old exposed cylinders on the radial engines, then to the light cowls, then to complete cowls, then to variable cowl flaps, then to automatically controlled cowl flaps, then to cooling fans, etc. Now the problem is similar. We are trying desperately to use a light, simple, fixed-area configuration to do a cooling job that is too extensive to handle in that manner. We cannot see one simple solution that will provide complete ground cooling at Mach Numbers up to $1^1/_2$ or 2 with ram temperatures from $-65°$ up to $+300°$. It doesn't appear practical or technically

sound to assume that we can make a simple fixed configuration that will do all that job. I think some of the other men will have something further to say about that. I hope so.

Concerning the oil system, it was mentioned, I believe by Mr. McCarthy, that we have a condition where the bearings have to operate without oil for a limited period and that the inverted position of the airplane is dependent upon that. Actually, the condition is, at this time, that we have solved the inverted scavenging problem so that the bearings will get oil, both upright and inverted. The condition in which the engine does not get oil is a limited condition of 0 *g*, in which, after the oil in the tank has been displaced and intermingled with air in the tank, whatever goes past the overboard dent line is going to blow out of it, and, if a hole or a dispersion of air and oil goes past the oil inlet, that is what is going to go into the engine. Therefore, in a temporary period of 0 *g*, there will be a question of the period of time in which the engine will be operating, not without oil but without new oil. Bearings in turbine engines, in not being heat-rejection lubrication systems, are merely lubrication systems, and a bearing well lubricated at the point that the flow is interrupted will operate for a prolonged period of time without failure. New and improved bearings are being worked on which have even better characteristics of that nature, partly for that and partly for firing up at −65°. The talk is going around now that the time from dead to an altitude of 60,000, 40,000, or 50,000 ft. is less time than I take to tie my shoes. When a pilot comes out and shoots off a cannon in his airplane to start the engine in 5 or 10 sec., which are the common numbers now, and has his seeing-eye dog in the front end all warmed up for him so he doesn't have to wait for that, and—voom—he's up to about 15,000 or 20,000 ft., I don't want to be around when he comes down if things don't work. The problems affecting the design of the lube system are like that, and they're being given careful consideration.

We greatly appreciate the comments on flexibility of accessories. It's not a simple one; it's going to be difficult to solve. As engine manufacturers we naturally go for the things that make the best engines. In other words, the combination of engine and airplane is usually best served when we arrive at, first, a good engine and then see if we can use that configuration in an airplane to its advantage. If we find that the best engine as developed penalizes the airplane, then we look for compromises. On the matter of accessibility arrangement of accessories, we find that the possible locations are limited by the basic engine itself. Let's take, for example, an engine that has a practically constant diameter compressor, diffuser, combustion chamber, and turbine housing. Where on that profile externally are you to locate any large pieces of equipment such as a 10-in. pad for a generator? You can't, on a small engine; it has to be located externally from the airflow passage; it cannot be in the basic barrel of the engine, at least within the length of the engine. Now, when you go into bigger and bigger engines, the ratio of airflow area to complete frontal area gets better. In other words, a big diameter engine, a yardstick or so in diameter, can't keep a hub of small diameter; the group diameter has to grow, giving you a reasonable area in the hub of the engine where you can bear accessories either by putting them in the dome or by splitting the inlets or by various other accessory arrangements. That gives you one point up in the front end, which is explained by Mr. Karanik's presentation of the axial and radial location of accessories. There are many things that can be done in the front. If you're going to have an engine that has a smooth cylindrical barrel, you have to spread your accessories pretty thin and pretty far to get them all on the outside of the engine. This results in the accessory problems on axial-flow engines which have been described. If we concentrate the accessories at a large point so that we have a common customer connection or aircraft hook-up point, then we get into a condition where we have a large removal space and the value of the small frontal-area engine has been lost and it is also detrimental to structure and arrangement of other equipment. The next best thing that can happen to us is to arrive at a configuration of a basic engine that has a thin waist (I can't say what waist, with Pratt & Whitney here), so if you have an arrangement of an engine which has a natural niche that can accommodate accessories, then it is logical to put them in that spot, thereby keeping the best engine arrangement and the best accessory arrangement and also eliminating the access problems that were mentioned. To be able to take a set of components—combinations of compressors and combustion chambers and turbines and nozzles—and spread them or arrange them in such a way that you provide internally, in that given length of frame, provisions for accessories is not in our thinking, and I doubt if it will be in others. You take too much penalty in the weight of the engine in the way of additional bearings, additional structural weight, and overall size of the engine.

Therefore, the trend toward taking the aircraft accessories from the engine and locating them in the airplane is welcome to us. In other words, we think it's a fine deal. In fact, if you take all the emergency systems off the engine (not all of them, but those that are reasonable), plus three aircraft pads ranging from 6 to 10 in. in diameter and envelopes almost up to the size of a speaker's stand, we will then be able to bring our accessories together in reasonable areas and provide good simple accessory and disconnect points for the engine. With the combination of accommodating rapidly expanding power requirements to run radar and to run all kinds of detection and range devices and armament with the magnification of those things that Mr. McCarthy pointed out, we don't see where we're going to put it on an engine unless we reach a compromise between the aircraft companies and our-

selves as to the best arrangement for an airplane; also, this does not present the prospect of getting a standard engine.

It looks more and more as though the spread between a global bomber engine and a local altitude interceptor is getting wider and wider. The engine manufacturers have been stifled (I won't say stifled, but definitely not encouraged) in respect to building special engines or doing the best job for specific aircraft projects. The Armed Services of this country have a standardized engine procurement program, or they have exhibited such tendencies; they would buy equipment that could be used in several projects, several aircraft at one time. This does not allow you the freedom of working with a great deal of flexibility to adapt a particular accessory arrangement to a particular airplane. Now, if we're coming to that, fine! However, in the past, this has definitely interfered with the problems of tying up a specific accessory configuration with a given airplane.

We believe in the tendency toward starters, the cartridge starter and the quick starting type of firer. There have been estimates made that they make a difference of thousands of pounds in weight in an airplane in time to climb to altitude, whether you take off immediately in a 5- to 10-sec. start or whether it takes you 40 or 50 sec. There's nothing in the engine which is prohibitive of doing that; it just means that on the front end where you crank you can't run it through an extensive gear train without a large penalty. You have to crank directly on to your main rotors. With bigger engines, it is likely that starting horsepower will increase some, but it will not go out of sight because the form of the engine is changing. It is no longer a simple engine, and it will be possible to fire parts of that engine in sequence, thereby not necessarily requiring that you crank the complete engine, say, on an extremely powerful jet engine of a new design. I appreciated this opportunity to comment.

Mr. Robinson: Well, you're right, Mr. Benedict, about being pushed, but it has always been that the engine installed today was obsolete before the airplane flew. That's one of the things that makes this business interesting.

Mr. Gerdan: It was with mixed feelings that I listened to the morning's discussion, and I have decided that, since the engine manufacturers are about to ship engines in metal containers, perhaps we ought to redesign the containers. Apparently, we ought to build in fuel tanks; we ought to build in power-generating stations, refrigeration plants, wing attachment means, and so on, and perhaps better rectify the life of these items immediately. Of course, we do have a couple of questions: Should we include the cockpit, and what size guns should we put on the container? Seriously, though, the installation problems of turbojet engines trouble us, if anything, more than they do the aircraft manufacturers, at least judging from our experience.

There are many simple items that the aircraft manufacturers and engine manufacturers should get together on and rectify. I believe that the correction of these items would help installation problems. We've seen complexity of fuel systems. There is one item particularly that helps make a fuel system complex—namely, the emergency fuel control. The emergency fuel control generally has its own pump, the various valves for crossing over to emergency from main, electrical wiring, and all that type of apparatus. All of this takes space, requires maintenance, and gets into trouble—I believe it gets into trouble to a sufficient degree that, if a careful statistical analysis were made of military operating conditions, we would find that the presence of the emergency fuel control has led to more trouble than would have been experienced if it hadn't been there.

I think we ought to remove the recent tendencies to include flowmeters on all engines as a part of the engine. I think it is in the wrong direction. I don't think that the flowmeters will give readings that are at all accurate. We've seen from previous discussions that we're losing fuel overboard. It seems to me that the development of an accurate tank level gage would provide far better results than the use of any flowmeter mounted on the engine.

As far as future fuel pumps are concerned, I think that some of the burden may be lifted from the aircraft manufacturers, and I foresee a trend toward the use of built-in centrifugal boost pumps on the main fuel pump. This won't eliminate the need for a fuel tank boost pump, but it most certainly will improve safety and reliability in the event of failure of the tank boost pump.

In engine cooling we agree that more data should be made available by us to the aircraft manufacturers, who are as badly in the dark as they are as to what's going to happen to the engine when it's in an installation. There are a couple of obstacles in the way of getting these data, however. First of all, we lack the test facilities to get the data over a wide range of operating conditions. I don't know of any one of us who is able to run an engine up to altitude conditions of 60,000 ft., which seems to be the magic number these days. We have no way of taking them up to those operating conditions, determining cooling requirements, and so on. We're dependent on Government agencies to get those data for us. There is a second obstacle—that is, that the aircraft installation requirements vary considerably from manufacturer to manufacturer. Take a pod installation or have a different setup on a fuselage installation—true that the engine components have to come down to the same temperature in each case and you have aircraft structural cooling requirements in each case, but the mechanism of providing that cooling can be totally different in the two cases. In that event it is rather difficult for the engine manufacturer to handle the

cooling job himself. I think that, as our speeds go up, we'll need another form of cooling for our engines which hasn't been discussed. If we consider flight at 700 to 1,000 m.p.h., 1,200 m.p.h., etc., we'll find that the cooling air (the air that could be used for cooling the engine) is going to go up in temperature and be roughly about 190° at 700 m.p.h. on a 100° day (and climbing from there on up to figures of 300° at high Mach Numbers).

We have bearings in the engines; we have oil in the engines. Unfortunately, the oil that is available today is an oil that really should not be pushed up in temperature much more than about 250°F., as a bulk temperature, although in local spots it can go up higher than that with some flash-off of oil. The bearings will have to be lubricated. With these high flight speeds we are going to have internal temperatures of the engines which are above the capabilities of the oil and therefore above the capabilities of the bearings to exist. That's going to require the development of oils to withstand the higher temperatures, and I believe it will also require some internal flow of air to insulate the bearings as well as possible from the extremely high temperatures that would be obtained by flow of heat through the turbine disc to the turbine journal. That problem isn't an attractive one to solve, but I am afraid that it will have to be solved.

There has been a lot of discussion of accessories arrangements. I might illustrate one of the things that we're up against. Let's assume an engine of 40-in. compressor tip diameter and a hub tip ratio of 0.5. That gives us a 20-in. circle at the front end of the engine to install all of the accessories—engine accessories and aircraft accessories. In one typical case that I know of at the moment, we would have to put in this space two 10-in. pads, one tach generator pad, two 6-in. generator pads, one 6-in. pad for a fuel pump, and one 6-in. pad for a fuel control. You have to put that in a 20-in. circle. I don't know how to do it. There are several choices that you may have. One choice is to put the power take-off and the starter pad on the front end of the engine. I believe then that you can also get a tach generator pad on there also, since it is a small pad. Then, to drive the other pads, one solution is to mount a gearbox on the outside of the engine—mount it directly to the compressor housing. There seems to be a fair amount of objection to that because it does interfere with the true circular shape of engine and therefore requires greater frontal area and greater fuselage dimensions. The other alternative that we would recommend is the use of a remotely driven gearbox to drive all the aircraft accessories, leaving on the engine only those items actually required for engine operation. Even those items may be rather difficult to get in that 20-in. circle I was speaking of, but we'll stand a chance of coming a little closer to it.

I don't agree that air should be used to drive aircraft accessories. For example, if we should require a 10 per cent bleed at normal rated thrust at sea level, as I recall it our thrust loss would be about 22 per cent specific fuel consumption, and the increase would be around 22–24 per cent at altitude at about 433 knots, 35,000 ft., again at normal rated thrust conditions. The thrust loss would be in the neighborhood of 25 per cent accompanying specific fuel consumption increase. Ten per cent air extraction is a high figure incidentally, and I doubt if a figure like that would be used continuously. But let's look at a 100 hp. extraction for that purpose. If the extraction is taken mechanically to a gearbox through a shaft at sea-level take-off conditions, the thrust loss would be in the order of about 0.005 per cent, with accompanying change in specific fuel consumption. The same thing done with air extraction to drive the turbine would result in about $2^1/_2$ per cent thrust loss and roughly about the same specific fuel consumption increase. Now, 100 hp. is a figure that is apt to be used continuously. Most of the aircraft manufacturers would, just as we, cut their own throats to get that 2 per cent in specific fuel consumption. We recommend then, and recommend strongly, the use of the isolated gearbox; we also recommend that the engine be designed so that shaft drives may be taken off either at the front or at any one of four radial positions at the front end of the compressor housing—taken off actually in five directions. That should be enough.

There is a further trouble with air extraction for power purposes. As we go up to higher and higher pressure ratios—let's again assume this rather high figure of 10 per cent extraction—if we can get all the aircraft manufacturers agreed that we're going to do it, we will then design the engines or the compressor with that much excess capacity in the compressor. Then our compressor and turbine will be matched in the high pressure ratio engines. But there will always be the heretic, if you want to call him that, among the aircraft manufacturers who is going to insist on mechanical drive and try to use that same engine—this high pressure ratio engine with mechanical drive that has a compressor that is 10 per cent over capacity and is no longer matched with the turbine. In addition, we've taken the equivalent of, in that case, roughly around 500–600 hp. for shaft power to throw the compressor and turbine farther out of match. If we are going to use air, everybody's going to have to do it. Two fellows can't use it and three others not, or vice versa.

There is much confusion on starting systems that are to be used. Actually, I think that Mr. McCarthy's figure of 50 hp. for the large turbojets should be doubled. We're being required to start our engines quicker and quicker. This 5- and 10-sec. starting time is not just a pipe dream; it is an actual demand made to the engine manufacturers. In the large engines, 100 hp. is going to be borderline for such starting times. The air turbine has some good characteristics, but it is obvious that for single-engined fighters—let's say the small airplanes—it is going to be difficult to accommodate the power source in the air-

plane. There won't be room. So we, as do other engine manufacturers, advocate the development of the cartridge starter and the liquid rocket starters. There is another possibility that is actually being used for other type engines under Arctic conditions. It wasn't long ago that I ran into a rather simple hydraulic starter used by the Ordnance Department to start some of its Diesel engines. This particular unit, mind you, is not designed for aircraft purposes; it is designed solely for these heavy hunks of cast iron. The starter output was 85 hp. using 2,200 lbs. per sq.in. hydraulic pressure, and the starter weight was 36 lbs. That same unit has the possibility of being adapted for aircraft purposes. On the ground it would require about a 10-gal. accumulator using the 2,200 lb. pressure. In the air, if we assume that 80 per cent of the starting power would come from windmilling and would require only 20 per cent from the starter, apparently an accumulator size of about $2^1/_2$ gal. would serve the purpose. That may afford one way out. If we should go to the cartridge and liquid rocket fuel starters, I think we should more or less agree that we have at the most a three-shot starter—say, one false start on the ground, one real start on the ground, and one for an air start—and limit it to that; otherwise the starting unit is going to be big and heavy.

I might touch on another item that has not been covered today but which does require some clarification. In one way it is an installation problem to us. The Armed Services require in our specifications that we present guaranteed engine data, which we do in the new military specs. They require a mass of data. The first time that these are computed for an engine and the curves drawn we have expended as many as 2,500 man-hours. You no sooner get that done when the aircraft manufacturers come along and they want us to tell them what the average engine will do and require all those data specified on an average expected basis. Let's do it one way or the other but not both.

Mr. Robinson: McCarthy, it looks like you and Karanik are going to be put out of business when this Gerdan shipping container becomes available.

Mr. Small: I think that Mr. McCarthy and Mr. Karanik have done an able job of summing up some of the multitude of problems that we jointly face as a manufacturing industry and in making a good end result—namely, a satisfactory airplane for our customers. Being third on the list of manufacturers, I can cross off a number of the items that I was going to comment upon because Mark Benedict and Dim Gerdan have covered them very well. So I'll touch upon a few of the things in somewhat more detail than the items that they covered. One of the points that was made by Mr. Karanik had to do with engine cooling and pertained particularly to afterburning engines.

I'd like to draw a couple of sketches to illustrate a point or two that I want to make, as far as the approach, at least, of one engine manufacturer—I think this applies to several—on the basic cooling problem of the variable nozzle and the exhaust pipe, which on the reheat engine in most cases is considered part of the basic power-plant design.

I'm drawing very simply a standard exhaust cone with a given tailpipe diameter and a kind of a jet nozzle. Here, this constant-diameter pipe is to represent roughly a reheat engine. Now, to date, for an engine, they're running with exhaust gas temperatures in the neighborhood of 1,250°–1,300°. The tailpipe wall has over it either insulation blanket with a moderate amount of cooling air flowing on the outside of the blanket—in fact, the aircraft structure—or the pipe may be bare with a stainless-steel shroud envelope with cooling air flowing in the annular space. In some installations a combination of the two is used. In other installations, neither insulation nor cooling air is used but rather there is room in the back end of the nacelle where a short tailpipe is installed. The structure is stainless steel. There is no cooling air whatsoever in the back end of the nacelle behind the engine fire-wall. This presents one theory of the problems of the engines as they are constructed today. They are essentially nonreheat unaugmented engines, except possibly for the take-off condition using water or alcohol for a limited length of time.

I think we, as engine manufacturers, will be the first to agree that, when you get into the problem of the reheat engine, the problem of engine cooling, as well as airplane cooling, takes on a somewhat different aspect. One approach that has been used for reheat engine design and afterburner cooling has been to inject the fuel through the pipe such that nonuniform injection is used, whereby the highest temperatures in the reheat burner appear in the center of the pipe, with progressively smaller amounts of fuel injected throughout it radially, so that the exhaust gas passing along just inside the pipe wall is essentially at the same temperature whether you are operating with reheat or not. That is, of course, an objective that is not an easy one to attain. But the basic problem of the engine manufacturer in this case that we're going to solve is that he is going to ship the packaged power plant with reheat burner and variable nozzle—the basic part of the engine. With him lies the responsibility of getting pipe life and, particularly, variable nozzle life, with the identical design that goes into the variable nozzle, the steels that are required, and the desire to cut down to a minimum nozzle leakage. You fellows have the objective of trying to get a design whereby the pipe-wall temperature will remain the same whether you're running no reheat or with reheat. On one occasion, an interliner had been installed in the after part of the pipe in much the same manner as interliners are put into the primary combustion chamber. The liner may be perforated, or it may be a continuous cylindrical sheet, terminating at the aft

end of the pipe. This is all right if you make sure that you have an annular layer of exhaust gas touching the outside pipe wall which tends to remain at about 1,250°–1,300° temperature.

From the nozzle standpoint, in some cases it is necessary to introduce a reasonable amount of, say, compressor discharged air to help cool the seal, and this, plus the interliner, would give an indication on test that with or without reheat the temperature of the pipe can be held in the vicinity of 1,250° to 1,300°. I think this is significant, because it indicates that, although your temperatures may get up in the 3,000° range during reheat, if those high temperatures can be confined to the central portion of the pipe, then the cooling problem, not only for the engine but also for the airplane, becomes considerably simplified. It makes it possible to begin to consider the continued use of insulation blankets and/or a shroud with a moderate amount of cooling air flowing either within the shroud or over the blanket.

Another comment that I think is in order has to do with the control of tailpipe temperature on existing production engines as they are going out the door today. Mr. Karanik mentioned the problem of control of exhaust gas temperature versus altitude and the fact that it tends to vary under altitude conditions as the altitude is changed at a given power setting. To that might be added two or three other problems that are all wrapped up in this matter of maximum limiting temperature and the control of it. One problem is the variation among production engines as they come off the line, one after the other, with slight differences in manufacturing tolerances and clearances. It is found that, as the engines come to test, there is a range in the maximum allowable exhaust gas temperature which is adjusted so that, by changes in their fixed conical nozzle or equivalent, you test the engine to be sure you meet the guarantee performance in the specs. But you may not, as an engine manufacturer, be holding the temperature at the maximum allowable limit. The desire of the aircraft manufacturer and the military services who are operating the airplanes is, of course, to get the maximum performance possible from a given engine and airplane combination. From that standpoint it means that there is the basic desire to be able to hold maximum limiting tailpipe temperature at military r.p.m., regardless of the change from one engine to another, say, at the time of overhaul, regardless of the ambient temperature of the day, the air speed, or the altitude. There's certainly a basic problem here that is rather easy to state but not too easy to overcome, because it means the development either of a variable nozzle, variable fin tabs, or some mechanical improvement in the jet nozzle along with an improvement in the automatic control system so that the end objective—namely, operation with any given engine at military r.p.m. or holding maximum limiting temperature—can be obtained regardless of the ambient of the day or the altitude.

Another point that was made by Mr. Karanik was that on present-day engines the fuel system is one of the most troublesome items. I think we can agree in general with that. Our experience has been that, of our troubles in the field (probably the troubles on accessories and, primarily, the control system, the main fuel control system, and the emergency system), those problems of the control system probably equal all the other service difficulties put together. In justice to the control-system manufacturers, I think it proper to mention that, when an engine design is laid down, compressor, performance, turbine performance, combustion system performance values are established and the engine is put together. In parallel with that, the control-system designer, in designing a control system, is going to take the engine and hold the desired end result—namely, a given speed for a given throttle setting. The facts sometimes turn out that the individual component efficiencies, or component performance, as the engine is laid down do not turn out to be in exact accordance with those figures. The result is, of course, that, even if the control system is doing the job it was designed to do, the control system gets a black mark because the deficiencies in other components are such that the design problem, if you please, for the control system is changed somewhere along the way. Of course, the control system, if it is going to meet the detailed requirements and the desires of the operating agencies, is inherently a complicated system in itself, and it has its share of troubles that can occur.

There is a conflict in philosophy on this matter of emergency control systems; Dim Gerdan mentioned that he thought we ought to do away with them. I think that we can pretty well agree with that. One of the basic troubles on emergency controls is that the emergency control system is put on the engine and the pilot learns to depend upon that as a primary system that he can use in the event of failure of the main system, and he puts his confidence and faith in it. If it is going to have prime first-order reliability, the emergency control apparently is going to be simple, and it cannot do all the things that the main control system will do. But the conflicting part of the overall philosophy is that the specifications and requirements are such that it is designed to have an emergency control that will do everything the main control system will do, thus, in effect, putting on two main control regulators. This simply means that you have a secondary stand-by system that the pilot can put his complete faith in, and yet it can become almost as complicated as the main system and therefore is subject to just about as many potential difficulties and troubles.

Mr. McCarthy made the point in his paper that no basic data are available on the performance of ejectors with primary nozzles that are other than conical. I have passed this paper along to one of our installations men to get some comments on his paper, and the paper came back to me with this note penciled in

the margin—"Mr. McCarthy's statement is all too true. We agree 100 per cent." So I went back and asked for a few comments, because we ought to have some additional explanation as to why more data aren't available on the overall problem of ejector design. Data are available on the so-called simple ejector using a conical nozzle, but when it comes to the reheat engine, with the generally adapted clamshell-type nozzle, General Electric, and I think probably the other engine manufacturers are faced with a problem like this. At the present state of the art, there are a number of different designs, each clamshell designed varying in detail. The number of different designs to work out an objective for each one would mean a long series of tests. It seems wise to wait until the variable nozzles are a little further along, a little more refined, before expending the time and energy that will be needed to get the basic data. This is one subject in which agencies like N.A.C.A., I think, are admirably set up to get basic data.

Another variable on the present jet nozzles is the matter of side leakage when the clamshells are in either their closed or partially open position, as well as leakage at all times past the seals that bear against the moving clamshell halves. Leakage *can* have an appreciable effect upon the performance of an ejector. At the present time, a great deal of work is being done to reduce that leakage, but each change in leakage amount will have an effect upon the combined performance of the variable nozzle and the cooling air ejector. On the other hand, the empirical approach is a rather formidable one, because the mixing length, the L/D ratio, changes with each nozzle position, as does the area ratio—the ratio of ejector exit area to nozzle exit area—primary pressure ratio, secondary pressure ratio, and the flow ratio. The geometry of the opening, as well as the leakage, has an appreciable effect upon ejector performance. It is a big problem and one that I think we can all agree we must find out more about as rapidly as we can.

Mark Benedict and Dim Gerdan commented in some detail on aircraft accessory drives. I agree essentially with the points they made. With regard to the starting problem, I believe that it was Mr. McCarthy's paper that showed around 45 to 50 hp. Dim Gerdan said he would like to double Mr. McCarthy's figure. I'd like to double Dim Gerdan's figure. Maybe the remaining two speakers will increase my figures. There are indications that on the higher pressure ratio engines, if you talk about present production engines having from 4 to 5, 4 to 1, or 5 to 1 pressure ratios and if you talk about pressure ratios that are 50 or perhaps 100 per cent higher than that, the starting power requirements are going up to rather astronomical figures if you combine the requirements of starting the higher pressure ratio machines with some of the requirements for interceptor aircraft where a fast start, much faster than is presently available, is required. I think, in general, the manufacturing industry—that is, aircraft manufacturers and engine manufacturers—by continuing to look at the problems jointly (keeping in mind that the end result is what counts and not the engine as such or the airplane as such but the airplane with all of its auxiliary systems and the power plant) find that it is the performance—the end result—that the user is concerned with.

If we continue to approach our problems on the basis that they're mutual problems rather than individual organizational problems, we will continue to make the same kind of progress that's been made in the relatively short time that the jet engine has been an active project in this country.

Mr. Jewett: Mr. Karanik and Mr. McCarthy have ably summarized the jet engine installation problem as it applies to fuselage installation. Mr. Karanik opened with a statement limiting his paper to this subject. I think these papers are excellent summaries of the conditions as they exist today. Certainly nothing that I can say will in any way detract from the conclusions reached. From our standpoint, however, they represent only a part of the problem. We do have nacelle installations in jet power pods as Mr. Karanik mentioned. These installations have their own peculiar set of requirements that have to be considered. Sometimes the best solution for these installations is quite different from the best solution in fuselage installation. We also have pressure from the military for fewer models of engines—fewer dash numbers. Their ideal would be one engine that would fit interchangeably in all types of airplanes, and they have some pretty good arguments for their proposal. The engine manufacturer is then faced with the problem of working out an engine configuration that will work in all types of airplanes without excessive compromise in any type of airplane. We would certainly like to build in fixes for all the installation problems that go with jet engine. But before you can build in a fix you must have a reasonably universal fix—something that will work in all sorts of airplanes. If you don't do that, the fix will be suitable for one type of airplane and be just so much useless gadgetry in other types of airplanes.

Now, for just a moment, I'd like to defend the engine designer. To do this, I want to take just one of the items mentioned by Mr. McCarthy and analyze it. I'd like particularly to consider the auxiliary power demands made on jet engines. Mr. McCarthy's bar graph, his Fig. 1, doesn't go far enough. When you consider the bomber type of aircraft, the power demands increase tremendously We almost always start out with a provision for a 90 kva. alternator. Ninety kw., at 80 per cent efficiency, requires about 150 shaft hp. This power is for the alternator alone. To this must be added any additional power requirement for d.c. electrical power, hydraulic power, or pneumatic power. Mr. McCarthy's power requirement, as shown in his Fig. 1, seemed moderate indeed compared to some we've seen. Let us further consider this 90 kva. alternator. To get 400 cycles, a.c. power,

we need 6,000 r.p.m. Now, while a modest frequency variation is permissible, the variation is not nearly enough to accommodate the variation in engine speed from idle to maximum power. Therefore, some sort of variable speed transmission is required. These can be mechanical, hydraulic, or pneumatic; all have been proposed, and some are being used. I want to talk about the pneumatic. If we put in some appropriate temperatures, pressures, and efficiencies, we find that, at sea level, military power approximately 1 per cent of the engine airflow will be required to drive the alternator. This amounts to about a 2 per cent loss in thrust. I didn't get together with Gerdan before, but I think this closely checks his figures. This seems like a reasonable amount. However, at military power at 55,000 ft., 600 knots, approximately 5 per cent of the engine airflow would be required. That is about 10 per cent loss in thrust. Although the cost is getting greater, you might consider that acceptable. Now comes the tough problem. The airplane manufacturer hasn't mentioned it before, but he most certainly will mention that he wants this power at engine idle for descent. At altitude and with jet engine idling, the air quantities really get tremendous. Probably something of the order of 50 per cent of the engine airflow might be required to drive a 90 kw. alternator at altitude with the engine idling; the thing gets so ridiculous that precision in that number is pretty bad. These percentages are representative values. They'll vary somewhat with the engine being considered. They could probably be cut in half if heat were added, as proposed by Mr. McCarthy in his Fig. 5. On the other hand, we are asking the auxiliary turbine to operate over a wide range of pressures, temperatures, and loads. Some loss in efficiency would have to be expected some place in that range. This would increase the airflow required. To summarize, the 10 per cent of the engine airflow that Mr. McCarthy requested is a practical number—it can be had. It's beginning to cost an awful lot in terms of thrust or fuel consumption, but it will work. However, 10 per cent will not be enough to drive a 90 kva. alternator with the jet engine idling. The 50 per cent required at the high altitude and low power is not a practical figure. It's way beyond the end of any performance curves that I have seen, and so it's hard to predict exactly what would happen. Probably the engine just stops running. With this example, I am merely trying to prove one thing: When you really put down all of the requirements for all of the different engine manufacturers and all the different types of airplanes which our engine might be used in, you find the problem becomes a lot tougher than it first appeared. If you underestimated or understated, you can make the problem sound easy. But when you get all the requirements for the various types of airplanes and try to make one engine meet them, you may well find that you have reached an impossible situation some place in the operating range. It's no wonder it takes a little time to get these features worked into the engine.

So much for the defense of the engine designer. I'd like to revert to my field now and say that, in our opinion, in the large multijet airplane, the air-operated auxiliary power system is extremely effective. We think they may see a lot of that in the big airplane. I don't want to get into any arguments with Mr. Karanik about what happens in fuselage installations. These big airplanes will probably have their jets in parts, and the mechanical drive system gets to be a little ridiculous in, for example, the B-52.

Now for Mr. McCarthy's conclusions. We find we can agree with most of them. The engine manufacturer will certainly have to supply both large capacity power take-off and large capacity air bleeds on future jet engines. Rather than several power take-offs, I'd like to suggest one power take-off that can be pointed in several directions—for example, forward, to either side, and up or down. We note that Mr. McCarthy said 10 per cent of the engine airflow from any one of several air bleeds. This sounds a little difficult, but 10 per cent from any two of several air bleeds wouldn't be so bad. His conclusion that the engine should have all the engine components mounted on the engine is one with which we can readily agree. However, the suggestion for alternate locations will be difficult to obtain. We can also agree wholeheartedly when he mentions the greater problems that lie ahead.

Mr. Gorton: I'd like to say as a starter that it seems to me that Mr. Karanik and Mr. McCarthy and my fellow sufferers from the engine industry have adequately covered the situation. However, at the risk of some repetition, I'd like to discuss one or two points from the standpoint of a man who has the job of making the jet engine a dependable power plant and one whose characteristics will keep the pilots happy. Before getting to the technical item, I'd like to say that Mr. Karanik's statement relative to the desirability of an alternate comparative power plant for a given aircraft installation gave me a chuckle. As a principal recipient of the pressure that can be applied to an engine man by this installation design philosophy I can personally certify to its effectiveness in keeping engine developers from going to sleep on the job.

With regard to the design of air inlet ducting for a jet engine, it seems desirable to point out an important consideration where engines with double-sided centrifugal compressors are to be installed. With this particular type of engine, the installation designer should keep in mind the fact that he has more to do than simply to duct the inlet air into the chamber in which the engine is installed with maximum efficiency. It has been found that, unless both compressors' inlets are fed with air at substantially the same pressure, an appreciable loss in overall installed engine performance may result. In other words, the aircraft will lose the benefit of some of the performance that can be developed in a test stand calibration of the engine. The reason for this is simple. The double-sided centrifugal impeller is, in effect, two garden-

variety single-sided impellers discharging into a common entry. If one side is effectively working at a higher altitude than the other side, its delivery pressure will be lower, with the result that air from the higher pressure side of the impeller will tend to back flow into the lower pressure side, thus lowering the compressor efficiency and overall delivery pressure. This compressor performance loss, of course, shows up as reduced thrust, higher fuel consumption, and a higher gas temperature. The end result naturally will be poorer performance in the aircraft. Therefore, it behooves the aircraft designer to so lay out the ducting such that both compressor inlets receive air at approximately equal pressures. If he does not, there is little that the engine man can do to give him back his lost performance.

Mr. McCarthy has enumerated the many and ever increasing demands for power extraction from the jet engine in the form of mechanical drives and air bled from the engine compressor. Mr. Gerdan and Mr. Jewett have presented jet data showing the effect on the engine performance at high compressor air-bleed rates. I believe that the engine man will be the first to admit that all these aircraft power requirements are real and justifiable. It would appear that a word of caution is in order. A practical limit exists for the power that should be extracted from a given size jet engine. Basically, a jet engine is developed to operate at a limiting gas temperature that will give reasonable durability and reliability to the hot parts of the engine. The most important part is probably the turbine. This temperature limit represents the ultimate performance of the engine which can be obtained without sacrificing reliability, durability, and service. Any power extracted from the engine increases the temperature under which the engine will run with a given set of conditions. If the power extraction requirements become high, the amount of the gas temperature increase becomes so large that the engine's output must be substantially reduced by such means as reducing the engine speed or by opening the variable-area propulsion nozzles in order to avoid operation above the safe limiting gas temperature. Any such reduction in the engine's output, of course, reduces the aircraft's performance, particularly in the matter of time to climb, which is so eagerly sought after in jet fighters these days. It can, therefore, be seen that, when power extraction requirements become high, some serious consideration should be given to determine whether the weight and complication of some auxiliary power source will compromise the aircraft performance less than would be the case if all power requirements were obtained from the engine. In simple language, the aircraft man just can't have his cake and eat it too. He must keep in mind that, in general, for every increment of power extracted from an engine he is losing an increment of maximum engine and aircraft performance. When power extraction requirements become as high as some of the studies of advanced aircraft indicate, the reduction in aircraft performance resulting when the power is all taken from the engine can well become sufficient to justify an auxiliary power source.

The matter of fuel systems has been pretty well discussed here, but I would like to agree with Mr. Karanik and some of the others who have preceded me on the matter of getting rid of the emergency fuel system. Because of early serious troubles, the thinking of the Armed Services tended toward the line that all engines should have an emergency, as well as a primary, fuel system. This thinking reflected itself in Government engine specifications that, in turn, forced the engine manufacturer to develop some extremely complex systems. It appears particularly important at the present time, but this can be reversed so that the engine man's efforts may be placed on development of a basically dependable primary fuel system. This view is taken because, as Mr. Karanik states, the added complexity in the design of the fuel system combining emergency features has been sufficient in some cases actually to reduce the reliability of the overall fuel system rather than increase it. There are many service experiences and troubles in fuel systems to back that up. It is a simple matter for an engineer with a Rube Goldberg turn of mind to sketch out diagrammatically a fuel system employing this gimmick and that gadget to take care of every conceivable failure under the sun. However, it is a totally different thing to develop and manufacture such a fuel system, even though it is fundamentally reliable. It is my belief, and I know that there are other engine men here who agree—it has been so stated—that, if the engineering effort that has been expended on failure protection features had instead been applied to develop a basically reliable primary fuel system, we would be delivering a more dependable jet engine to the aircraft manufacturer today.

Discussion

Mr. Robinson: I fully subscribe to that last statement.

Mr. McCarthy: As the engine manufacturers were making their comments, I started making a list of notes. As it progressed, I found that I was making a list of things that I agree with more or less. However, there are a few small points that I'd like to bring up. Mr. Benedict mentioned that clamshell nozzles were not the best. We all agree with that. I can't help but blow our own horn a little bit here. McDonnell Aircraft has developed a nozzle that is not a clamshell, and it has demonstrated that it is possible, practical, and desirable to build a nozzle that has many segments that form a circle under all areas and which has bellows-type seals against leakage. The nozzle is not ready for production, but it is a good nozzle and has flown many hours.

Mr. Gerdan mentioned flowmeters. We certainly agree that they are not accurate and that they should not be on the airplane, but the Armed Services don't

agree with Mr. Gerdan and me. I would like to make the comment that, if it is going to be any place in the airplane, it should be on the engine in the high-pressure side of the fuel system. We can't stand the losses in our fuel.

With regard to cooling information and the facilities available in engine manufacturing plants for obtaining it, we agree that they can't go to altitude, but what we would most like to have is basic information that could be obtained in the laboratory. I think we ought to get together a little later on and see if we can thrash that out. With regard to bleed-off, 10 per cent is admittedly high. I was looking too far in the future, I believe, and I should have said that I was considering primarily the altitude condition. Of course, at sea level, the bleed-off rate would be much less and not necessarily continuous. With regard to starting horsepower, 50 hp. is low. I plotted the curve primarily to show the trend, and the curve values were taken from engine specifications where they listed the horsepower required to maintain cranking r.p.m. and not to accelerate to cranking r.p.m.

Mr. Small mentioned fuel control troubles, and we agree that they are many and varied. With Westinghouse engines—at least the ones we've had the most experience with—the trouble with fuel controls is their adjustment in the first place; it's not maintenance after they're adjusted. We think that they're completely reliable and agree that there should be no emergency system.

With regard to the ejector problem, we agree that we should wait until we get standardization of variable nozzles before we begin getting basic data. In the meantime, while we're waiting, we suggest that we run qualitative or quantitative tests of typical installations so that we can get the feel of the situation and design better airplanes. We suggested this to the N.A.C.A. the better part of a year ago, but at least at that time they didn't realize the problems the way we did and they didn't go ahead with any sort of testing. They may have changed their minds since then; I certainly hope so.

Mr. Gorton said. "We can't have our cake and eat it too," and we agree. But you can't blame us for asking. We think that in asking for it we'll stimulate the kind of discussion we've had today and progress in the future.

Mr. Collins: I guess everybody knows why I came up to say something about the ejector and ejector program. We of the N.A.C.A. agree that the case of the simple nozzle should be taken care of first, and our investigations with the simple nozzle have been completed, covering a wide range of pressure ratios. We think we have also prepared an analogy so that cold nozzle tests can be properly correlated with hot tests. In other words, there are so many different configurations of the ejector nozzle that we felt we should give you the basic data so that the manufacturer could take his own configuration of both tail designs, interference from tail sections, etc., and so that he could run those data on model tests and predict fairly accurately how his full-scale nozzle would perform. With regard to the ejector data of the clamshell, we agreed with McDonnell Aircraft that it was desirable to run these tests. However, since there was so much question about the configuration and since these configurations would effect the results, at that time we were not prepared to run them. In fact, we had not completed the basic data. However, in conjunction with the operators with whom we ran the tests on the simple ejector nozzle, we are now set up for a typical clamshell installation, and these tests are in progress. I hope that reports and information will be coming out to you gentlemen shortly.

Mr. Newton: I think these papers on installation matters are extremely interesting, especially those bearing on the dual or the emergency fuel system. I think we can succeed in dropping the emergency fuel system if the reliability of the present fuel system on the engine improves. As a matter of fact, on multiengined aircraft, the Air Force has gone along with us already in the elimination of the emergency fuel system.

In the mention of these auxiliary gearboxes or drives to provide power for accessories, there may be one advantage that we haven't made use of before and this is that it's so frequent now in our operations with large engines that we have the failure of the engine just because of the failure of the accessories, such as the generator or alternator. With a jet engine installation, it would, of course, be extremely serious on a long-range mission for one generator, used for airplane equipment, to overheat and require the shutting down of that complete power plant. By use of a disconnect similar to the cabin supercharger disconnect in the auxiliary gearbox, or power source, if we separate it by a shaft from the main engine, I think we could accomplish an advantage.

I'd like to say one word on behalf of the bleed. The engine manufacturer is, of course, confronted with the demands of the single-engine user for auxiliary power and for the aircraft manufacturer's power. In the case of the multiengined airplane, our bleed requirements are rather modest. We use large alternators and motors for hydraulic purposes and other sources of power throughout the airplane, and here we find on an extremely large long-range bomber that our maximum bleed requirements stay below 2 per cent under the low-altitude conditions. In fact, $1^1/_2$ per cent would be more realistic. Therefore we don't feel that it is any severe handicap on the large airplane to bleed our air and then use it in a pneumatic system. However, that type of system is not too desirable in view of its complication. If there were a good auxiliary power unit, we would always be interested, but we are stopped by the fact that auxiliary power units don't have the altitude characteristics of the main engine

and they do not provide the economy of the main engine for the supply of that power.

Mr. Maloy: I don't think that any discussion of installation requirements would be complete, at least from a civil standpoint, unless some mention were made of the problem of thrust measurement. Being in the business of measuring aircraft performance and relating that performance to field length, route, and terrain, we're disturbed by some of the reports and some of the information we have on possible deterioration in thrust between overhaul periods. In order to have a firm grasp of that situation, it appears desirable to have some means of simply examining the amount of thrust available before each flight. I say simple, and I say at least as reliable as the method that we now have available in reciprocating types. Therefore, I'd like to ask a question of these gentlemen as to whether there is any extensive work going on in what to us, from the civil standpoint, is an extremely important problem.

Mr. Benedict: There is definitely work in progress on a simple reliable thrust meter. The measurement of thrust in flight has been under study, I guess, ever since the first one flew, and we battered from pillar to post as we do in most of these things—first we go too far in one direction and then in the other and gradually level off somewhere about the right place. The initial efforts called for measuring gas flow, pressures, and temperatures right at the throat of the nozzle on a complete airplane installation and for flight testing it. This is laborious and expensive. It also has inherent inaccuracies. The foreseen problem with the variable nozzle made it much more difficult. Imagine trying to measure now, in flight, pressures and temperatures in the plane of the variable throat. It would be extremely difficult. We have been working extensively on a pressure ratio device that is primarily an ambient static pressure balanced against a turbine outlet pressure, treating the whole nozzle or nozzle afterburner combination as a pressure ratio device. For the simple engine with a fixed nozzle, it is a reality. For the variable nozzle, it is in process. At this stage we have a gross thrust meter that is less the ram drag at the front. This perhaps is not ideal. Adaptation of that for net thrust meters is in progress. I think that by the time we have engines for transport use, we'll have a direct cockpit-reading gage thrust meter. Its accuracy may not be within a $^1/_2$ per cent or even in that neighborhood, but it will be a good quantitative gage.

Mr. Gerdan: Probably the first form of gas turbine that will see civil application will be the turboprop. The turboprops, at least as we'll put them out, will have built-in torque meters. I daresay that those of other manufacturers will be equipped in the same manner. That will help answer that problem.

Mr. Small: Another thing seems to me as significant in connection with Mr. Maloy's question. It will have to do with the time it takes to develop an adequate thrust meter, especially for use with variable-nozzle engines, as well as the cost to do the job. This has to do with whether the primary interest is in a thrust meter that will measure accurately the actual net thrust of a particular engine or whether the requirement is one—and this applies, of course, not to single-engined airplanes but to multiengined—of getting a comparative check of thrust of a multiengined airplane, say before take-off. If that is the requirement, I believe the overall design of thrust meter can be simpler, because we are primarily after a comparison as to what one engine out of four or six is doing as compared with remaining engines. If that is the requirement, I feel sure that the development of a thrust meter to do that would be considerably simpler than the development of a thrust meter to measure as accurately as possible, on an absolute basis, the thrust of each engine.

Lt. Helms: I am no longer connected with flight test, I haven't been for the last 5 or 6 months, but I still am engaged in the turbojet engineering problem. I noted with interest one of the engine manufacturers' statements that, if the engine manufacturer could be allowed greater elasticity in his design, he could come up with a better engine. I couldn't possibly argue with that. However, I think that possibly, without us realizing it, our whole concept is changing. We might look back to a statement made 3 or 4 years ago by Mr. de Havilland, at Farnborough, when he said that the reason the British had had such good luck with their fighter designs was that they built a good engine. In fact, I think he said they worked like "bloody" blazes to build a good engine. Then they built the fighter airplane that would go with it. But the Americans built the airplane they wanted and then built an engine to pull it. Well, I think that we are getting around to the British way. In our contracts that we allot, we're having to do it first for an engine and then build an airplane around it, because the same thing that's holding up your research, holds up ours—cost.

Let me get back to another thing, however—the emergency fuel system. I am acquainted with the servomechanism of both the J-42 and the J-33. Speaking just as a pilot, I don't think that you will ever convince me that I'm not going to need that emergency system. Because of many reasons, I wouldn't want to go into any discussion of how many hours we've operated, but I will say that on numerous occasions, if we hadn't had the emergency system—and we've had very good luck with the Rochester unit—I don't think we'd ever have gotten the aircraft back. I don't say that by increasing the effectiveness of it and making it more reliable you won't convince me, but as it stands now I don't think you will. I think that that would be a contributing factor also, particularly with a pilot just out of flight training or with people with little flight experience. They'd be reluctant to step in a

(*Continued on page 80*)

The Link Instrument Flying Jet Trainer

REALISTIC ON-THE-GROUND TRAINING of pilots in the flight, engine, and radio-navigation techniques required for the operation of jet aircraft is provided by the Instrument Flying Jet Trainer, Type C-11, recently completed for the U.S. Air Force by Link Aviation, Inc. The first model of the new Jet Trainer, popularly named the "Linktronic," has been accepted by the Air Force for use by the Training Command. Its acceptance followed an extensive test program participated in by the manufacturer and the U.S.A.F. Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio.

In external appearance, the Link Jet Trainer resembles a miniature Diesel or electric locomotive. It is 14 ft. in length, weighs 3,750 lbs., and can be disassembled into four sections that can be wheeled through a 3-ft. 6-in. door (Fig. 1). Although the trainer itself does not move, it provides complete flight realism, including 360° aerobatics about three axes and the effects of wind up to 120 m.p.h., rough air, thunderstorms, and lightning.

The student's cockpit (Fig. 2) is located in the forward section of the trainer and is covered with a hood during operation. All the controls and instruments of the C-11 function just as they would in an actual high-speed flight. Rates of roll, climb, and acceleration are faithfully duplicated, and the controls are loaded so that pressures vary with air speed.

The student's performance may be monitored from the instructor's console (Fig. 3), located in the rear section of the trainer, by a series of eight instruments that duplicate exactly the readings of their counterparts in the cockpit. The student's flight path is traced on an actual Radio Direction Finding chart. Student's errors are indicated by a series of 23 colored lights—red for an error in technique, amber for the result of the error, and blue for the operating condition of the airplane.

This new Air Force development is essentially a combination of three trainers—flight, engine, and radio navigation—in one. Integration of these three training objectives is based on the proposition that a pilot being trained to fly instruments in a jet airplane must simultaneously be well versed in the total problem of operating his aircraft. The proficient jet pilot must know

FIG. 1. Link Instrument Flying Jet Trainer, sectionalized, with hood removed. Quick disconnects facilitate rapid disassembly and reassembly.

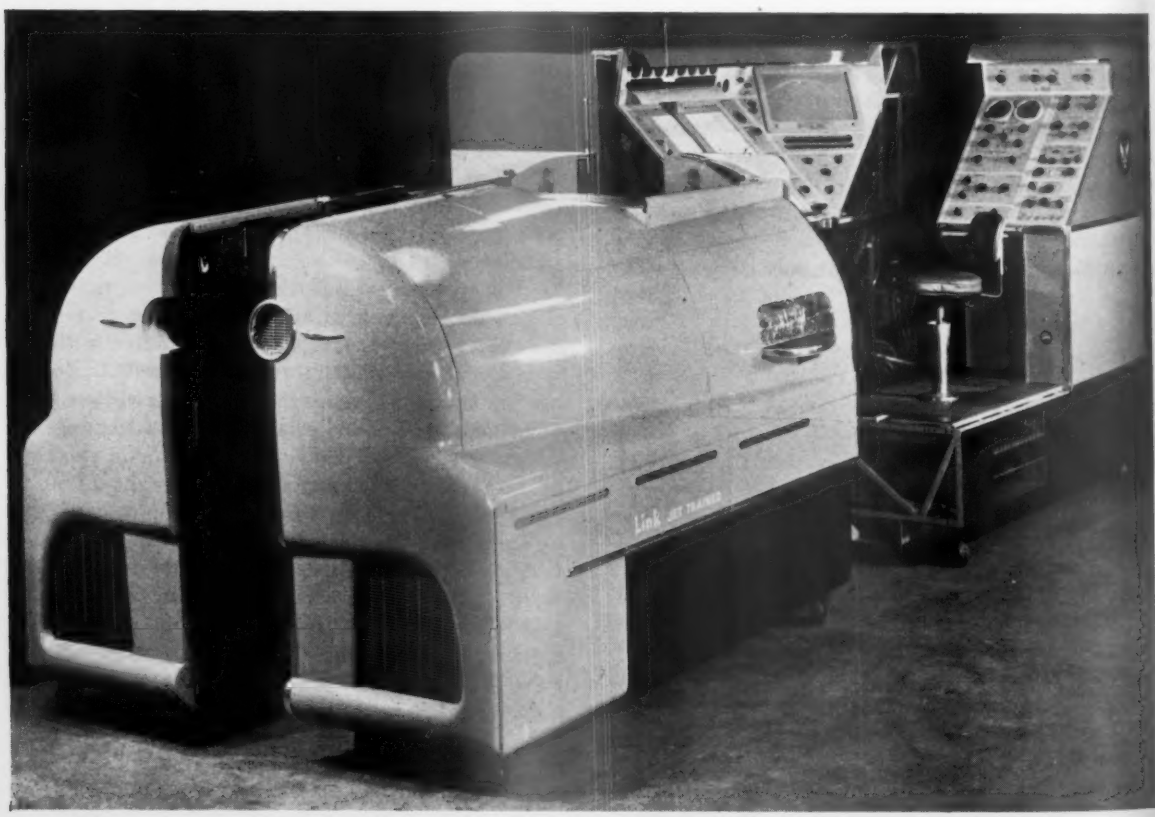


FIG. 2. Main panel of student's cockpit, which conforms closely to that of single-engined jet fighter.

not only his radio-navigation and instrument procedures but also how to operate his engine within limits, how to manage fuel consumption properly, and how to deal accurately and swiftly with emergencies.

Training For Emergencies

Accordingly, an integral part of the C-11 Instrument Flying Jet Trainer is a series of emergency controls with which the instructor, sitting behind the student's canopied cockpit, can introduce a wide variety of operating troubles. These controls provide the instructor with means of testing the pilot's alertness, his ability to cope with emergency situations, and his ability to develop a habit of checking airplane operation controls and instruments while flying by instruments. These emergencies may be introduced at any time during a problem and require the same corrective measures or procedures as they would in an actual aircraft.

Emergencies that can be introduced are: engine failure, engine fire, engine overspeed, fuel-pump failure, low fuel pressure, hydraulic-system failure, hot tailpipe, fuselage-tank puncture, pitot and wing ice, and lightning flash.

In addition to emergency controls, the instructor also has a Pilot Failure Over-Ride or so-called "angelic" switch that by-passes all pilot errors and time delays in engine operation and flight technique other than crashing into the ground. When this switch is actuated, the board is cleared of all troubles, and the student may start his problem over again. Also provided is an Aircraft-Engine Reset switch, which may be used to replace an engine or aircraft disabled by pilot error.

Radio Facilities

Of major importance in the training of jet airmen are the navigational facilities available in the C-11. For the first time in any ground training device, it is possible to give a pilot instruction in the use of VHF, omnirange, and the off-set course computers that are coming into use under the Air Navigation Development Board Interim Facilities Program.

The trainer's facilities include a Radio Magnetic Indicator, Distance Measuring Equipment, an ID-249 Cross-Pointer Indicator, and an Arbitrary Course Computer. These enable a pilot to determine his position and course through visual reference to instruments rather than through aural signals as is the case with older low-frequency equipment. Low-frequency controls are provided, however, for radio-compass and aural-null procedures.

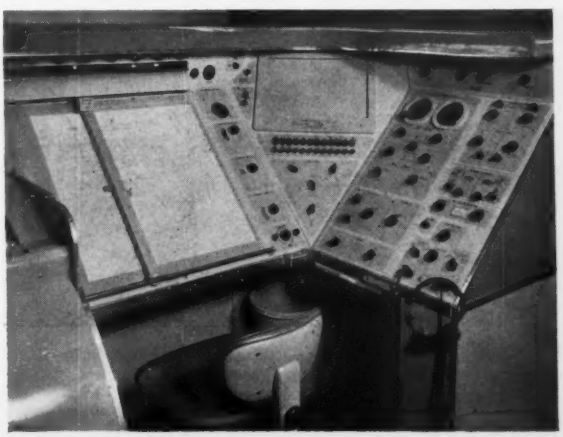
The instructor's console provides two station locators with all necessary controls for setting in type of station, frequency, call letters, maximum range, and approach bearing. By resetting Station Number 1 as Station Number 3 as soon as the student has tuned to Station Number 2, the instructor can simulate an infinite number of radio stations and make possible cross-country flights of more than 1,000 miles. Once the stations have set at proper geographic locations, all signal transmissions are automatic, and the instructor has only to simulate such voice communication as he chooses.

By means of duplicate instruments (RMI, DME, ID-249, and Altimeter), the instructor can also follow a student's performance on ILS approaches. Possessing this range, azimuth, and elevation information, he can then give practice in standardized GCA let-down procedure.

A constant record of the student's flight path is maintained by a new type of automatic recorder located on the instructor's console. This traces a true ground path on an actual Radio Direction Finding Chart, 22 in. square. The instructor can set or reset the pen at any point by means of a manual drive.

(*Continued on page 52*)

FIG. 3. Instructor's console. On the left are the duplicate instruments (only partly visible at the top), the row of colored monitoring lights, and the standard aeronautical chart for tracing student's flight path. On the right is the fuel and radio control panel. The V-shaped center panel contains the twelve push-button switches that enable the instructor to introduce emergencies at any time.



Eliminating the "Tap-Tap" Department

By

Welman A. Shrader

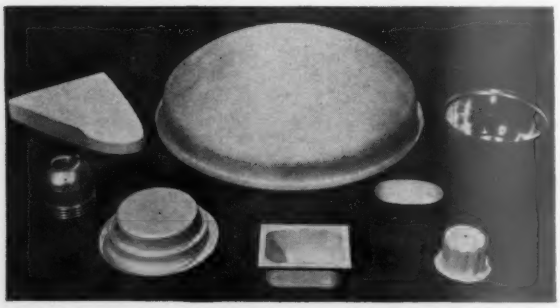
TO THE AIRCRAFT INDUSTRY goes the credit for developing many new products and production methods that have had wide acceptance and application in other fields of industry. Not the least of these, and one that promises to advance considerably the art of metal-forming, is a recent development by Glenn L. Martin company engineers. The new process, affectionately dubbed "Marform," is another typical example of aircraft engineering ingenuity.

While it was developed to meet a specific problem peculiar to the manufacture of airplanes, the Marform process should prove a boon to any producer of deep-drawn metal stampings.

In an industry where mass production may be measured in terms of a 100, 50, or even fewer airplanes or components, metal-forming, through the use of costly steel dies, is difficult to reconcile. A compromise method, known as the Guerin process, has therefore been widely exploited by aircraft manufacturers during recent years. Essentially, this is a process in which a rubber blanket is used as a substitute for the normal female portion of the die. It definitely offers an opportunity to save a considerable amount of money in tool cost on short production runs of applicable parts.

Where the stamping operation involves either a straight bend in the metal, stretching of metal, or a combination of the two, the Guerin process adequately fills the bill. In such formations there is no tendency for the metal to wrinkle. However, in shrinking metal into a more complicated shape, such as a convex flange or a deep-drawn cup, the tendency to wrinkle definitely does exist.

These resulting wrinkles have caused the establishment in most aircraft plants of a facetiously called "tap-tap" department. Here, many man-hours are lost in tapping, pounding, and grinding out intolerable wrinkles and deformations.



An assortment of metal parts formed by the Martin Marform process. The parts shown range from 0.010 aluminum to 0.109 deep-drawing steel and represent a large variety of shapes and sizes which have been successfully formed with the new metal-forming method.

To prevent these wrinkles from forming in the first place was the challenge that set Martin's tool research engineers on the search for a more efficient method of metal stamping. Out of it came Marform—a process that combines the forming ability of a steel die with the economical tooling of the Guerin process.

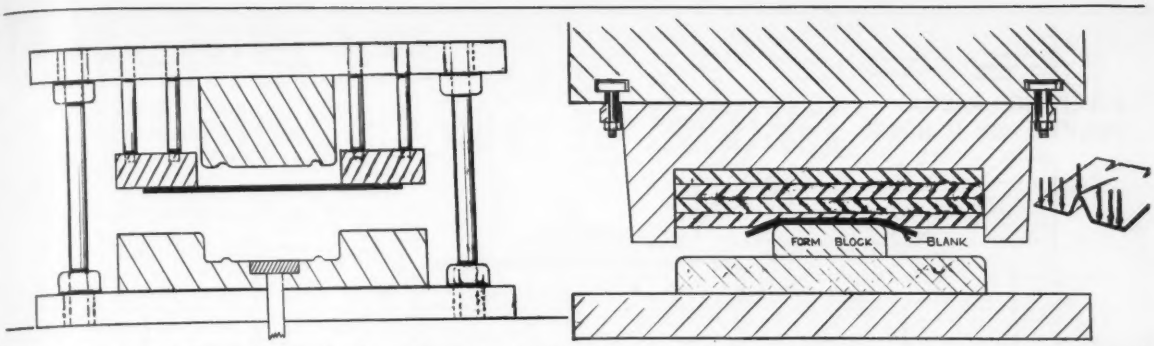
As may be seen from the accompanying diagrams, Marform utilizes a solid block of rubber as the complete female die. This not only eliminates the costlier half of matching steel dies but also saves on the tooling of the male die. Since the rubber half of the die has a certain amount of resiliency, softer materials, such as Masonite or cast Kirksite, can be used for making the punch portion of the die for short runs on soft materials. A further saving is realized on the setup time of such a tool, since the male and female portions do not have to be matched.

Although the Marform process does not give the embossing definition of a steel die, at least in its present state, it outperforms a steel die in many cases and in more important aspects. For example, the forming ability of a tool or material is generally judged on the basis of the depth of round cup it will draw on a given size of punch. This can also be stated another way by saying that the basis of drawability is the percentage reduction in area which can be made on a blank in one forming operation.

A 40 per cent reduction in area is generally expected on a steel die when forming aluminum alloys, for example; a reduction in area of 50 per cent can be attained if extra diligence is exercised. However, a reduction in area of 57 per cent is considered normal in Marform work on the same material, and figures as high as 70 per cent have been attained in testing operations.

In like manner, a cup depth equal to the radius is normally expected from a steel die, while a depth equal to one and one-half times the radius is normally expected in Marform on the same material and depths equal to one and one-fifth times the diameter, or two and two-fifths times the radius, have been attained in certain cases. All of this means that the Marform process can sometimes form a part in one operation that would otherwise require two operations.

There are several apparent reasons for this added formability. One of the most obvious reasons is the fact that the rubber has a certain cushioning effect and therefore prevents rapid application of strain at any point on the metal in contrast to the situation in a steel



(*Left*) A schematic illustration of a simple steel draw die, showing male and female elements, pressure pads, and die set arrangement. (*Right*) Illustration of the Guerin process. It will be noted that a rubber pad is used as the female die pressing the metal blank over the male form block.

die where localized applications of strain may on occasion be severe.

The rubber also exerts a lateral pressure during the forming operation which is a direct result of the applied forming pressure. This lateral pressure has the effect of locking the metal already formed to the male portion of the tool. This prevents an accumulation of strain at the punch radius and thereby causes the strain to be distributed uniformly over the complete surface of the piece to be formed. The importance of this fact is readily demonstrated by the fact that most steel-die formed parts that fail, fail when the top pops out of the part, with the failure along the line of the punch radius.

The prevention of concentration of strain at the punch radius not only enables the part to be formed deeper but also causes the part to be more satisfactory in certain applications where uniform thickness is important.

There is another related advantage in the fact that the rubber locks the material against the punch. This arises from the phenomenon that local elongations in metal can safely be higher than elongations over a relatively longer gage length. The rubber automatically causes the metal to be strained over a much shorter gage length by locking it just above the instantaneous point of forming and therefore provides the elongation available from the shorter gage length.

The third factor that enables the Marform process to form a deeper part in one operation is the ability of the machine to provide an exact required pressure on the material at each desired depth of stroke. This pressure can be varied in either direction; in other words, it can start low, be increased, and then drop off; or it can gradually be increased from start to finish; or it can be started at a high value and then dropped gradually to a lower value. The pressure variation can be infinite within the minimum and maximum values, and therefore it is not a series of steps.

There are several other advantages from a forming standpoint in the Marform process, such as the precision with which a given shape can be formed. Sheet-metal parts can be made to a tolerance of ± 0.002 in. A tolerance of ± 0.005 in. is commonly obtained on parts where the shape is sufficiently rigid to maintain such accuracy.

The Marform process also has an advantage on extremely thin materials, which are often difficult to form. Material as thin as 0.010 in. thick has been successfully formed, and a 0.012-gage cup was deep-drawn to the point where the depth of the cup was nine-tenths of the diameter of the cup. Gages as thick as 0.675 in aluminum alloys and 0.102 in 1010 steel have been formed. This is not necessarily the maximum but only represents the thickest gages formed to date.

The problem of applying finishes to formed shapes is sometimes critical from the economy standpoint. This is particularly true of polished surfaces. It is more economical to polish material in the flat state and then form the parts. This results in marred finishes when the normal processes are used. However, round cuts have been successfully formed on the Marform machine where the material had been previously coated with such finishes as Vinyl, Aircraft paints, and crackle paints. This experiment has also been performed with polished material.

These few examples of Marform advantages may be expanded further and summarized briefly as follows:

(1) The Marform process often permits deeper draws than is possible with conventional methods in one operation.

(2) This process makes possible such reductions in tooling costs that it offers a great advantage to low-, as well as high-volume production.

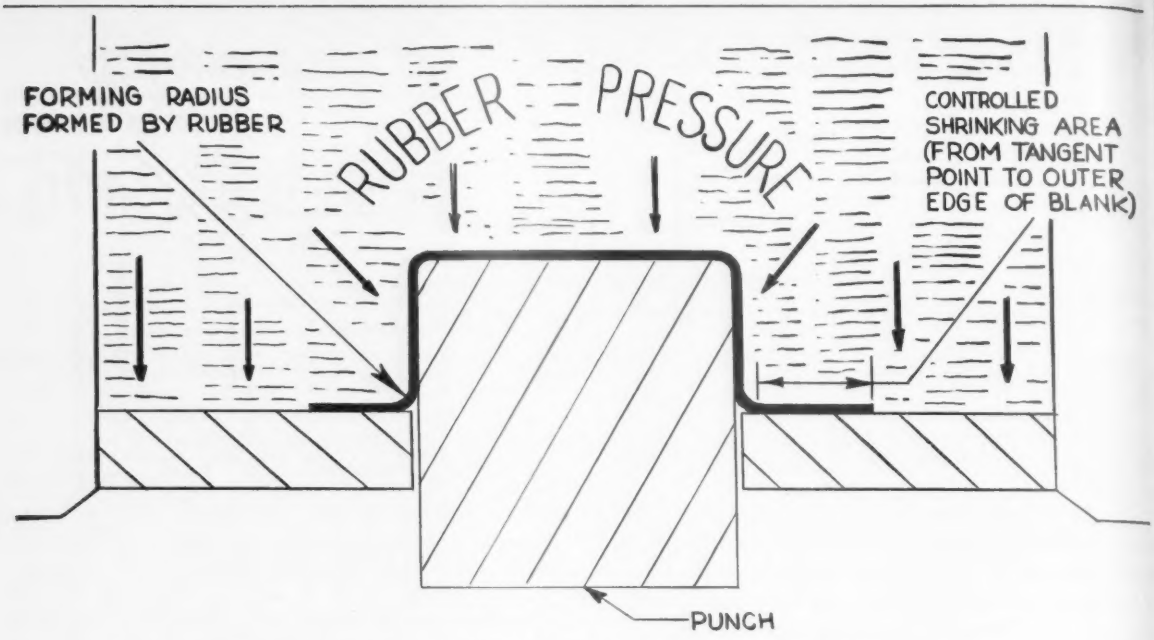
(3) The Marform process offers considerable economies for those industries that have frequent product design changes.

(4) Eliminates finish forming of parts by hand as now required on parts formed with rubber in the hydropress.

(5) Several different parts of complicated contours, each having similar pressure curves, can be formed at the same time.

(6) Parts can be formed of varied materials and thickness within a reasonable range with little or no effect on tooling.

(7) Strains in the formed parts are distributed more uniformly throughout the piece, resulting in formed parts relatively free of internal strain concentration.



RUBBER PRESSURE MUST BE GREAT ENOUGH TO ALLOW MATERIAL TO SHRINK WITHOUT WRINKLES

This sketch illustrates the Marform punch and the Marform plate on which the metal rests. These two elements constitute a Marform tool. The rubber in the Marform retainer is also illustrated, along with the fact that the rubber pressure is exerted in all directions against the part.

(8) The material wall thickness in a deep-drawn part is maintained practically uniform from the blank to the finished formed part.

(9) Surface finishes of the metal and coatings, such as some paints and plastics, are not affected by the forming operation.

(10) The Marform process can be adapted readily for hot-forming.

(11) Greater tapers without wrinkles can be formed than by other current processes except spinning.

It is evident from the foregoing that, once again, aircraft engineers have made a major contribution to the production "know-how" of American industry.

In announcing the fact that Marform units would be manufactured and marketed by Hydropress, Inc., New York City, C. C. Pearson, President and General Manager of Martin said, "The Glenn L. Martin Company is not a machine manufacturing concern. We are concentrating our efforts on the design and manufacture of aircraft and closely related products.

"Research, as always, continues to be pressed in as many directions as may be beneficial to the aircraft program, and, when an especially worth-while development of more general utility is perfected, such as the Marform process, we prefer to license it to specialists in that particular field, so that it may become accessible to all who may benefit from its use."

The Link Instrument Flying Jet Trainer

(*Continued from page 49*)

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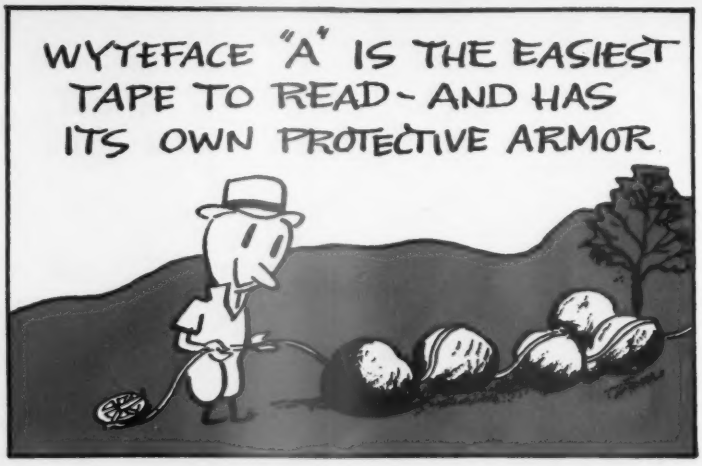

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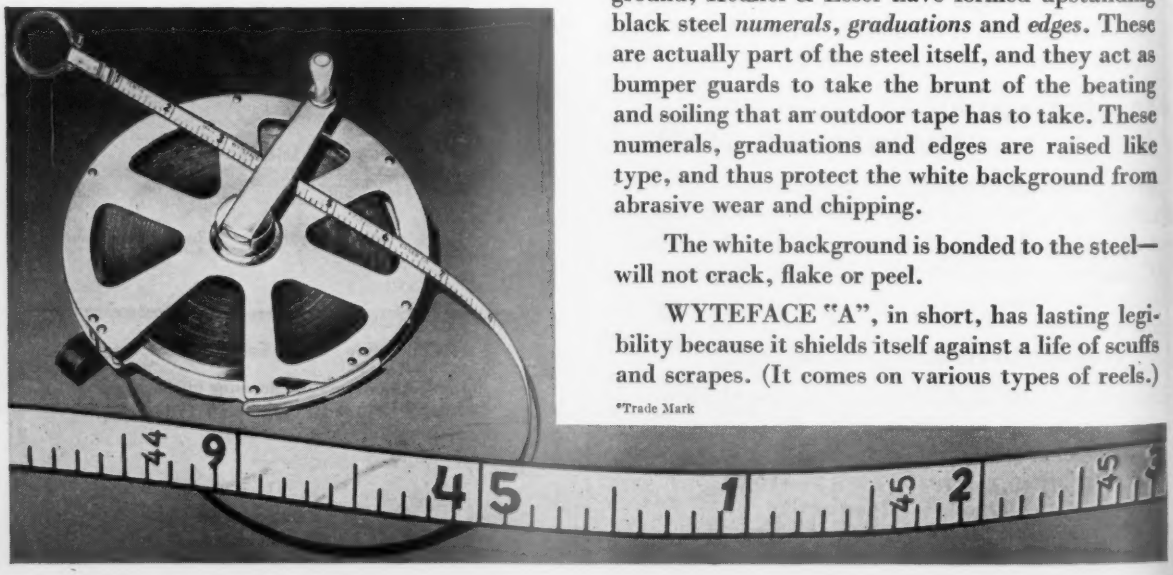

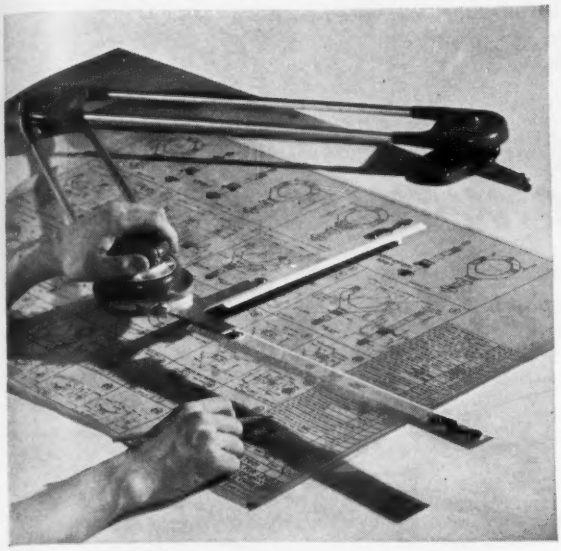

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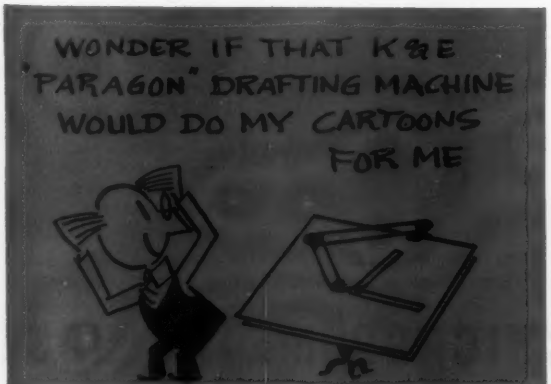

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Aerodynamics (2)

BOUNDARY LAYER

Approximate Calculation of the Laminar Boundary Layer. B. Thwaites. *The Aeronautical Quarterly* (*Royal Aeronautical Society, London*), Vol. 1, Part 3, November, 1949, pp. 245–280, figs. 16 references.

All the known velocity distributions from exact and approximate solutions are collected and compared in a manner that shows their potentialities or limitations when used as the bases of approximate methods. The comparison shows that it is possible for an approximate method to yield the exact values of the more important characteristics of a flow. A method of calculation is constructed which gives good results, is simple and speedy in application, and can be used with confidence in regions of increasing pressure, and which, in particular, predicts with good accuracy the separation of flow.

Some Notes on a "Magnus Wing." James Fox. *The Aeroplane*, Vol. 78, No. 2013, January 6, 1950, p. 17, illus.

A rotating drum installed in an experimental wing section and turned by external power caused increases of 100 to 200 per cent in the lift of a wing section by producing the Magnus effect, which increases the airflow velocity over the top and reduces the velocity over the bottom surface of the wing.

Experimentální Vyšetřování Vývoje Mezní Vrstvy na Profilu (Experimental Investigation of the Development of the Boundary Layer on an Airfoil Section). Zbyněk Jaňour. *Prague, Letecký Výzkumný Ústav* (*Aeronautical Research Institute*), *Zprava cis. 6*, 1940. 51 pp., illus., diagrs., figs. 18 references. (English summary.)

Using hot-wire apparatus and an airfoil section similar to the N.A.C.A. 4422 section, measurements were made in a closed-circuit wind tunnel with a free stream of circular cross section, 60 cm. in diameter, to determine the stagnation point, points of maximum and minimum velocity in the boundary layer, velocity distribution, turbulence, and the transition vortex. Oscillograph records were taken at distances of 0.49 mm., 0.135 mm., and 0.12 mm. from the surface, and lycopodium powder was used to indicate the transition or separation at stall. In the region of the transition vortex the boundary layer can be divided into three sections that are characterized by differences in the velocity distribution that range from slow movement in the upstream section, a center of minimum velocity, and a rapid increase to high turbulence in the downstream section. The results obtained fail to confirm the idea that there is a connection between the transition vortex and the stalling phenomena. The existence of turbulence in the neighborhood of the stagnation point was found, but was not fully explained.

Flight Experiences and Tests on Two Airplanes with Suction Slots. Stuper. (*ZWB, Forschungsbericht Nr. 1821*, July 1, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1232*, January, 1950. 104 pp., illus., diagrs., figs. 50 references.

The Stability of the Laminar Boundary Layer in a Compressible Fluid. Lester Lees. *U.S., N.A.C.A., Report No. 876*, 1947. 47 pp., figs. 18 references. U.S. Govt. Printing Office, Washington. $0.30.

CONTROL SURFACES

A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile. R. E. Bolz and John D. Nicolaides. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 252* (Sherman M. Fairchild Publication). 30 pp., illus., diagrs., figs. 9 references. Members, $0.65, Nonmembers, $1.00.

Based on the assumption that the aerodynamic forces acting at any point on a lifting surface are linearly dependent upon the local angle of attack at that point, the theory of pure rolling motion is applied to the experimentally observed motion of a finned missile in supersonic flight in order to determine how well the actual motion is represented by the theory, the suitability of the Aerodynamic Range at the Ballistic Research Laboratory, Aberdeen, Maryland, for the proposed free flight roll technique, and in order to determine certain aerodynamic coefficients associated with the motion over a range of Mach Numbers from 1.67 to 2.7. Values for the aerodynamic coefficients are also derived using the linearized supersonic theory and are compared with those obtained from experiment. The results indicate that the actual motion is well represented by the theory to within the small experimental

errors and that excellent reproducibility of the aerodynamic coefficients in roll is obtained. Furthermore, the results show a fairly good correlation with the linearized theory when applied to aerodynamic surfaces at 16% thickness as employed on the missiles used in the reported tests.

Lifting-Surface-Theory Aspect-Ratio Corrections to the Lift and Hinge-Moment Parameters for Full-Span Elevators on Horizontal Tail Surfaces. Robert S. Swanson and Stewart M. Crandall. *U.S., N.A.C.A., Report No. 911*, 1948. 16 pp., figs. 17 references. U.S. Govt. Printing Office, Washington. $0.15.

FLUID MECHANICS & AERODYNAMIC THEORY

A Mechanical Analogy for Hypersonic Flow. H. Reese Ivey. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 263* (Sherman M. Fairchild Publication). 10 pp., illus., diagr. 1 reference. Members, $0.35, Nonmembers, $0.75.

A mechanism was developed to simulate the different flows of air at altitudes such as those encountered along the flight paths of missiles. Hard elastic pellets are used to represent the molecules of a real gas in hypersonic flows at speeds in excess of Mach Number 5. At lower levels the mean-free paths of the molecules are very short and the air can be considered as a continuous medium, in which case the laws of gas dynamics apply. Strong, sharply defined shock waves occur, and fully developed boundary layers are formed. In the higher atmosphere, the mean-free paths of the molecules become larger but are still small by comparison with the missile size. Shock waves, which are at least one mean-free path-length thick, are no longer sharply defined but are noticeably thick and diffuse, and the boundary layer behaves differently from those in continuous fluids. Since the velocity at the missile surface is no longer zero, the missile is operating in the "slip-flow" region of flight. At a still higher altitude, in free-molecule flow, the molecular mean-free path becomes comparatively large, and shock waves and boundary layers are no longer recognizable. Photographs show the flow around models of airfoils, cylinders, and other bodies, depicting the gradual degeneration of shock waves as the effective operating altitude is increased. The apparatus is useful in obtaining information about slip flow and free-molecule flow, and for qualitative force measurements.

Lift on Inclined Bodies of Revolution in Hypersonic Flow. G. Grimminger, E. P. Williams, and G. B. W. Young. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 247* (Sherman M. Fairchild Publication). 27 pp., diagrs., figs. 19 references. Members, $0.65, Nonmembers, $1.00.

The importance of body lift lies in the fact that at moderate angles of attack and high Mach Number it can constitute an appreciable part of the total lift of a winged missile. An attempt has been made to analyze body lift in hypersonic flow by an approximate method and, together with a correlation of existing experimental data, to indicate the probable variation of body lift over a wide range of Mach Number extending from low supersonic to hypersonic. The method of analysis of hypersonic flow over inclined bodies of revolution has been denoted as the hypersonic approximation. It is an improvement on the Newtonian corpuscular theory of aerodynamics. The hypersonic approximation method accounts, in addition to the impact (Newtonian) forces, for the centrifugal forces resulting from the curved paths of the air particles.

Readers' Forum: On Simple Plan Forms in Supersonic Flow. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, p. 127. 2 references.

Readers' Forum: Second Order Two-Dimensional Supersonic Airfoil Theory. Bruno W. Augenstein. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, p. 126, fig. 2 references.

Data on Shape and Location of Detached Shock Waves on Cones and Spheres. Juergen W. Heberle, George P. Wood, and Paul B. Gooderum. *U.S., N.A.C.A., Technical Note No. 2000*, January, 1950. 69 pp., illus., figs. 8 references.

Readers' Forum: Note on Rotational Gas Flow. James A. Broadwell. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, pp. 123, 124, figs. 2 references.

Mach Number Functions for Ideal Diatomic Gases. J. V. Foa. *Cornell Aeronautical Laboratory, Inc.*, October, 1949. 135 pp. Tables of Mach Numbers and their functions, which can be used for air with sufficient accuracy for many aerodynamic problems. The figures range by internals of 0.001 from Mach Number 0.000 to 5.000.

Experimental Investigation of a Stationary Cascade of Aerodynamic Profiles. William T. Sawyer. *Zurich, Eidgenö-ssische Technische Hochschule, Institut für Aerodynamik, Mitteilung Nr. 17*, 1949. 78 pp., illus., diagrs., figs. 46 references. Verlag Leemann, Zurich. 12 Sw. fr. (In English.)

A valid and practical "blade efficiency" for a cascade in terms of force components was used to reflect the practical influence of flow variables, and various means of observing boundary-layer separation and transition were shown to be consistent with each other. Accuracy of measurement of flow conditions was substantiated by means of the continuity equation applied to three-dimensional observations. The investigation included a study of Reynolds Number and turbulence effects upon typical blade spacing and gave experimental verification of the Ackeret continuum-cascade method of blade design. Reynolds Number is of practical importance in relation to turbine performance under part-load or low-speed operation and under full-load operation at large kinematic velocities such as in aircraft at high altitudes. Within certain limits, the effect of turbulence intensity far outweighs that of turbulence scale. A blade form produced according to the Ackeret theory yielded a tangential force component within 1.5 per cent of the theoretical Euler equation component, and a pressure drop within 3 per cent of the theoretical. A cascade constructed according to the theory produced, with maximum efficiency in excess of 97 per cent, an actual mean angle of turn of the airflow within 1.7 per cent of the desired turning angle.

Odpor Podélně Obtékané Desky Při Malých Reynoldsových Číslech (The Resistance of a Plate Placed Parallel to the Flow at Low Reynolds Numbers). Zbynek Janour. *Prague Letecký Výzkumný Ústav (Aeronautical Research Institute), Zpráva Č. 2*, 1947. 51 pp., diagrs., figs. 17 references. (In Czech with English summary.)

To investigate frictional resistance in a laminar flow at Reynolds Numbers lower than those assumed in the Blasius formula—that is, at magnitudes of the order of 10 to 10^3, measurements were made in the oil channel at the Göttingen Institute for Fluid Research. Results, including Reynolds Numbers from 12 to 2,235, show that the values of the resistance coefficient are higher than those given by the Blasius formula. In the range of Reynolds Numbers 10 to 10^3, the coefficient can be approximated by means of the formula developed in the paper within an average accuracy of three per cent. For Reynolds Numbers greater than 10^3, the resistance coefficient slowly approaches that of the Blasius formula. The lower limit of Reynolds Numbers in which the Blasius formula is valid can be extrapolated to approximately 2×10^4. The upper limit is given by the transition of turbulent flow in the boundary layer at Reynolds Number about 5×10^5. If the plate is not of infinite span but has a straight edge parallel to the flow, an additional resistance arises at the edge and its magnitude in the range of Reynolds Numbers 30 to 2,300 can be expressed with an average error of 6.2 per cent.

La Théorie Générale des Mouvements Coniques et Ses Applications à l'Aérodynamique Supersonique. Paul Germain. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 34*, 1949. 203 pp., figs. 9 references.

INTERNAL FLOW

Contribution á l'Étude des Pertes de Charge Singulières. C. H. Cottignies. *France, Ministère de l'Air, Publications Scientifiques et Techniques, No. 239*, 1949. 116 pp., figs. 37 references. Service de Documentation et d'Information Technique de l'Aeronautique, Paris. 420 fr.

PARASITIC COMPONENTS & INTERFERENCE

Datos Estadísticos Sobre las Resistancias Parásitas de los Aeroplanos. Juan Jose Re. (*La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Físicomatemáticas, Revista*, December, 1944.) *La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Físicomatemáticas, Instituto de Aeronautica, Publicación No. 14*, 1944. 8 pp., figs. 2 references.

PERFORMANCE

Cálculo de Performances para Velocidades Subsónicas. Clodoveo Pasqualini. (*La Plata, Argentina, Centro Estudiantes de Ingeniería, Revista*, Vol. 24, No. 90, December, 1947.) *La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Físicoma-*

temáticas, Departamento de Aeronautica, Publicación No. 19, 1948. 25 pp., figs. 9 references.

The known effects of compressibility on the aerodynamic characteristics of airfoils and wings are summarized, and some experimental results are collected. A method is given for the first approximation calculation of the performances of jet and airscrew-jet engined aircraft. A compressibility ceiling is defined and calculated for two extreme cases.

STABILITY & CONTROL

Podélná Úhlová Obratnost Letounů (The Longitudinal Angular Maneuverability of Aeroplanes). Vilém Kočka. *Prague, Letecký Výzkumný Ústav (Aeronautical Research Institute), Zpráva Č. 4,* 1947. 81 pp., figs. (In Czech with English summary.)

By analyzing the motions of an airplane immediately after the deflection of the elevator in response to different stick forces, an effort was made to establish a measurement called the "angular maneuverability number" which is based on the angular speed of the airplane around its axes at the instant when its straight, steady flight is first affected by a stick force of constant value. Analysis of the transitory motion and of the quasi-steady motion suggests that the quasi-steady motion is decisive for the characteristics of the longitudinal angular maneuverability, and it does not matter whether the stick force is applied constantly or by a "quick deflection" method. Comparison of the angular maneuverability of two airplanes must be made at the same values of relative mass, chosen as a "normal" value, and must be adjusted for altitude. At stick forces higher than those stipulated, the "maneuverability number" decreases, but the cause cannot be explained on the basis of available data.

A Theoretical Analysis of the Effect of Time Lag in an Automatic Stabilization System on the Lateral Oscillatory Stability of an Airplane. Leonard Sternfield and Ordway B. Gates, Jr. *U.S., N.A.C.A., Technical Note No. 2005,* January, 1950. 29 pp., figs. 11 references.

A Theoretical Investigation of the Effect on the Lateral Oscillations of an Airplane of an Automatic Control Sensitive to Yawing Accelerations. Arnold R. Beckhardt. *U.S., N.A.C.A., Technical Note No. 2006,* January, 1950. 27 pp., figs. 8 references.

An Investigation of the Stability of a System Composed of a Subsonic Canard Airframe and a Canted-Axis Gyroscope Automatic Pilot. Robert A. Gardiner, Jacob Zarovsky, and H. O. Ankenbruck. *U.S., N.A.C.A., Technical Note No. 2004,* January, 1950. 51 pp., illus., figs. 8 references.

Pressure-Distribution Measurements on the Tail Surfaces of a Rotating Model of the Design BFW-M 31. M. Kohler and W. Mautz. (*Göttingen, ZWB, Forschungsbericht Nr. 704,* September 30, 1936.) *U.S., N.A.C.A., Technical Memorandum No. 1220,* December, 1949. 38 pp., illus., diagrs., figs.

Effect of Horizontal Tail on Low-Speed Static Lateral Stability Characteristics of a Model Having 45° Sweptback Wing and Tail Surfaces. Jack D. Brewer and Jacob H. Lichtenstein. *U.S., N.A.C.A., Technical Note No. 2010,* January, 1950. 46 pp., illus., diagrs., figs. 6 references.

A Study of the Use of Experimental Stability Derivatives in the Caclulation of the Lateral Disturbed Motions of a Swept-Wing Airplane and Comparison with Flight Results. John D. Bird and Byron M. Jaquet. *U.S., N.A.C.A., Technical Note No. 2013,* January, 1950. 79 pp., illus., diagrs., figs. 10 references.

Application of the Laplace Transformation to the Solution of the Lateral and Longitudinal Stability Equations. G. A. Mokrzycki. *U.S., N.A.C.A., Technical Note No. 2002,* January, 1950. 59 pp., figs. 22 references.

Movimiento y Establidad Dinamica de un Avion. Jose P. Lombardi. (*La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Fisicomatemáticas, Revista,* Vol. 4, No. 1, pp. 1–25.) *La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Fisicomatemáticas, Departamento de Aeronautica, Publicación No. 18,* 1947. 26 pp., figs. 5 references.

Movimiento y Establidad Dinamica de un Avion. Jose P. Lombardi. (*La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Fisicomatemáticas, Revista,* Vol. 4, No. 2, September, 1946, pp. 179–198.) *La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Fisicomatemáticas, Departmento de Aeronautica, Publicación No. 21,* 1948. 20 pp., figs. 6 references.

WINGS & AIRFOILS

The Load Distribution Due to Sideslip on Triangular, Trapezoidal, and Related Plan Forms in Supersonic Flow. Arthur L. Jones and Alberta Alksne. *U.S., N.A.C.A., Technical Note No. 2007,* January, 1950. 37 pp., illus., figs. 9 references.

Spanwise Loading for Wings and Control Surfaces of Low Aspect Ratio. John DeYoung. *U.S., N.A.C.A., Technical Note No. 2011,* January, 1950. 36 pp., figs. 10 references.

Damping in Pitch and Roll of Triangular Wings at Supersonic Speeds. Clinton E. Brown and Mac C. Adams. *U.S., N.A.C.A., Report No. 892,* 1948. 9 pp., illus., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.15.

Theoretical Calculations of the Supersonic Pressure Distribution and Wave Drag for a Limited Family of Tapered Sweptback Wings with Symmetrical Parabolic-Arc Sections at Zero Lift. Julian H. Kainer. *U.S., N.A.C.A., Technical Note No. 2009,* January, 1950. 14 pp., figs. 7 references.

Subsonic Flow Over Thin Oblique Airfoils at Zero Lift. Robert T. Jones. *U.S., N.A.C.A., Report No. 904,* 1948. 7 pp., figs. 3 references. U.S. Govt. Printing Office, Washington. $0.15.

Airplane Design & Description (10)

Evaluation Criteria for Transport Aircraft. R. D. Kelly, R. L. McBrien, and L. G. Kelso. *Aeronautical Engineering Review,* Vol. 9, No. 1, January, 1950, pp. 37–39, figs.

AIRPLANE DESCRIPTIONS

O Grande Quadrimotor Italiano "Breda-Zappata." (The Big Four-Motor Italian "Breda-Zappata"). *Velocidade,* Vol. 10, Nos. 11-12, November-December, 1948, pp. 12–14, illus.

Flying the Cessna 172 Seaplane. *Aircraft and Airport,* Vol. 12, No. 1, January, 1950, pp. 15, 16, illus.

Convair's Improved C-99. *Aero Digest,* Vol. 60, No. 1, January, 1950, pp. 13, 108, illus., diagrs.

New "Flying Classroom" for U.S.A.F.; The Convair T-29, Specially Adapted for Mass Navigational Training. Stanley H. Evans. *Flight,* Vol. 56, No. 2140, December 29, 1949, p. 820, diagr.

Convair Ready to Convert to Turboprop. *Aviation Week,* Vol. 52, No. 1, January 2, 1950, pp. 11, 12, illus.

Comet Discussion; Lines of Development, Sales Policy, Performance and Experience to Date (The de Havilland Aircraft Co., Ltd.). *Flight,* Vo.. 56, No. 2140, December 29, 1949, p. 814, illus.

Fuelling the de Havilland "Comet." *Shell Aviation News,* No. 137, November, 1949, p. 9, illus.

Tonic Sonics; Reflections on American Research, with Special Reference to the Douglas Skyrocket. Stanley H. Evans. *Flight,* Vol. 57, No. 2141, January 5, 1950, pp. 16, 17, illus., diagr.

DC-3, Super DC-3, Mamba DC-3. *Interavia,* Vol. 4, No. 11, November, 1949, pp. 673–676, illus., diagr.

The Emigh Trojan. Bob Arentz. *Flying,* Vol. 46, No. 2, February, 1950, pp. 30, 31, 56, 57, illus., diagr.

Speed With Comfort. *Hawker Siddeley Review,* Vol. 2, No. 4, December, 1949, pp. 8, 9, illus. Avro Canada C.102.

First Details on Russian-Built Transport (IL-12). *Aviation Week,* Vol. 52, No. 4, January 23, 1950, pp. 23–25, illus., diagr.

The Martin P4M-1 Mercator for Anti-Submarine Warfare. *The Martin Star,* Vol. 9, No. 1, January, 1950, pp. 3, 16, illus.

YF-93A (North American) Makes First Flight. *Aviation Week,* Vol. 52, No. 5, January 30, 1950, p. 13, illus.

Teacher's Pet (North American T-28A). *Aircraft and Airport,* Vol. 12, No. 2, February, 1950, p. 11, illus., diagr.

A Polish Ultra-Light Pusher (Pegaz). *Flight,* Vol. 57, No. 2141, January 5, 1950, p. 20, diagr.

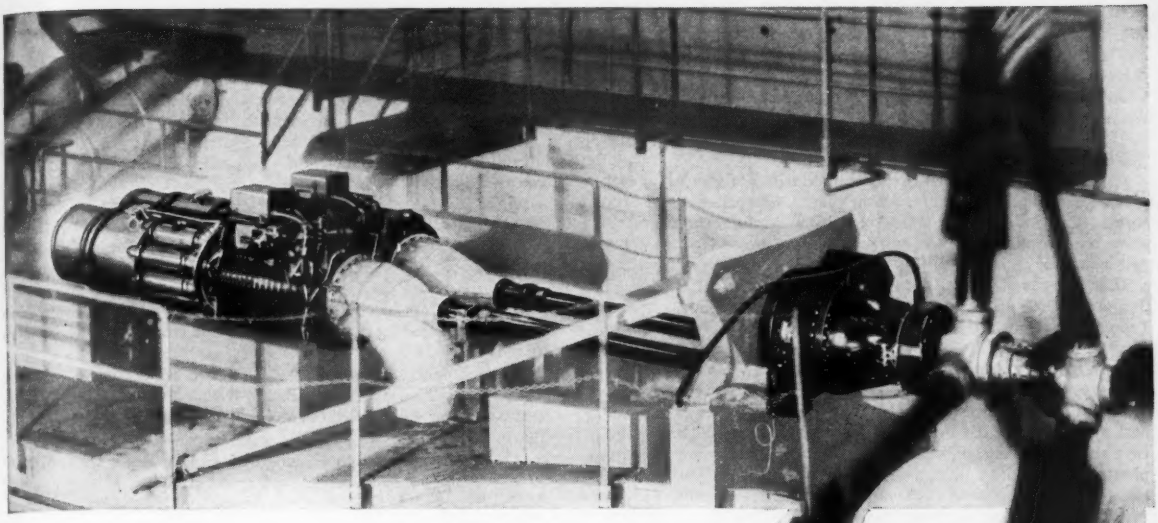
Progress with the (Percival) Prince Feeder Liner. *The Aeroplane,* Vol. 78, No. 2013, January 6, 1950, pp. 7, 8, illus., fig.

Avro's All-Weather Fighter; First Flight (CF-100). *Aircraft and Airport,* Vol. 12, No. 2, February, 1950, p. 7, illus.

Canadian Contender; Flight Looks Over the Avro (C.102) Jetliner at Malton. *Flight,* Vol. 57, No. 2141, January 5, 1950, pp. 13–15, 22, illus., diagr.

Avro (C-102) Jetliner. *Shell Aviation News,* No. 137, November, 1949, pp. 12, 13, illus.

A French Pusher (Courlis SUC10, Société d'Études et de Constructions Aero-Navales). James Hay Stevens. *Aeronautics,* Vol. 22, No. 2, January, 1950, pp. 48–51, illus., diagrs.



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Machmaster (Vickers Supermarine 510). *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 44, 45, illus.

First in the Field (Vickers Viscount 700). *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 30, 31, illus.

Aviones Argentinos (Aircraft of Argentina). *Aeronáutica Contental*, Vol. 1, No. 2, May, 1948, p. 3, illus.

U.S. Commercial Aircraft. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 29–35, illus., diagrs.

Condensed descriptions of accommodations, features, dimensions, performance, weights, power plants, equipment, and other data. Type designations used by each manufacturer and by government agencies, and photographs and three-view drawings are included.

U.S. Personal Aircraft. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 36–51, illus., diagrs. Specifications, pictures, type designations, dimensions, equipment, features, and other information. Prices are quoted in many cases.

U.S. Military Aircraft. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 52–61, illus.

Descriptions and photographs of bombers, fighters, transports, and trainers of the Air Force and Navy, listing available information about their design, construction features, dimensions, power plants, armament, and performance. Names and type designations used by the armed services and the manufacturers are given.

Foreign Aircraft. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 65–80, illus., diagr.

Information about design and construction features, power plants, dimensions, performance, type numbers, and service ratings of commercial aircraft of British, Australian, French, Canadian, Czechoslovakian, Italian, Dutch, Norwegian, Swedish, Swiss, and Turkish manufacture.

LANDING GEAR

No More Skids for Airplanes. Arthur J. Bent. *SAE Journal*, Vol. 58, No. 1, January, 1950, pp. 63–66, illus., diagrs. (Extended summary of a paper: Aircraft Decelostat—A Device for Wheel Slide Protection.)

The Caterpillar Takes to the Air. Hermann Schoenen. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 40, 41, 112, illus.

Review of the development of the track-type landing gear and its installation in military and commercial airplanes. The mechanism and its advantages are explained.

PRELIMINARY DESIGN

Some Factors Affecting Large Transport Aeroplanes with Turboprop Engines. A. E. Russell. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, pp. 67–93, Discussion, pp. 93–106, 122, figs. 24 references.

How to Achieve Producibility in Aircraft; Airframe Manufacturer's Ideas, Engine Manufacturer's Ideas. Hall L. Hibbard and E. B. Newill. *SAE Journal*, Vol. 58, No. 1, January, 1950, pp. 42–46, fig. (Excerpts from a panel discussion.)

Lockheed's Proposal for Jet Transports. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, pp. 13–15, illus.

Airports & Airways (39)

The Development of an Airborne Radar—Radar Beacon Method of Making an Instrument Approach to a Landing Runway. R. W. Ayer and F. C. White. *American Airlines System, Flight Engineering, ANTC Branch, Navy BuAer Contract NOa(s)-9006, Task No. 6, Final Report*, July 21, 1948. 69 pp., diagrs., figs.

Air-borne radar interrogating two ground radar beacons that reply with delayed pulses, provides a safe method for approaching and aligning with a runway under instrument conditions, down to the limit of safe operational use of altitude-measuring equipment. It was tested at a ceiling of 200 ft. and visibility of one-half mile. The method is primarily useful for radar-equipped aircraft landing in fields not equipped with other instrument-landing facilities or as a check during normal let-downs. It is free from the possibility of dangerous errors because the equipment is self-checking and independent of other instruments or facilities. Alignment within 25 ft. of the runway center line has been achieved regularly by pilots unfamiliar with instrument-flying techniques and without radar experience.

Development of an Airborne Radar—Single Radar Beacon Method of Flying Precise "Off-Set" Tracks. R. W. Ayer, F. C. White, and T. J. Drummy. *American Airlines System, Flight Engineering, Operational Development Branch, Navy BuAer Contract NOa(s)-9006, Task No. 3, Final Report*, September 15, 1949. 25 pp., illus., figs.

It was required to determine, by experimental beacons and flight operations, the accuracy with which an airplane can be flown manually, or by manually controlled autopilot, or by full automatic control, homing on a radar beacon, or flying on an offset course that is neither toward nor over the beacon, in varying degrees of crosswind; and to determine the feasibility and accuracy of automatically flying on an arbitrary course within the coverage area when using one or two ground beacons. Using either the UPN-4 or the CPN-6 type of ground beacon with a nose-antenna installation, tracks may be flown in any direction at altitudes within the line of sight, and offset in any direction within the radar range except headings where the ground facility is astern of the airplane.

Some Operational Aspects of Distance-Measuring Equipment in the Transition Air Navigation System. J. Wesley Leas. *Aeronautical Engineering Review*, Vol. 9, No. 1, January, 1950, pp. 31–36, illus.

An Aircraft Approach Procedure; Some Tests with Aircraft Using Distance Measuring Equipment and the Multiple Track Radar Range. J. G. Downes. *Institute of Navigation, Journal*, Vol. 3, No. 1, January, 1950, pp. 43–60, figs. 5 references.

A History of the Development of Navaids and a Prophecy for their Future. Peter Sinclair. *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 34–36, figs.

Sharmain. D. N. Sharma. *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 32, 33, figs.

A radio navigational aid named See-Hear Associated Range Multiposition Indicating Navigational System is designed to enable small airplanes as well as large and well-equipped craft to operate and be guided to destination by a combination of voice signals interlocked with bearing, range, and position indicator pulses from ground beacons.

Airport Approach Light Issue Revived; Slope Line Dropped. *American Aviation*, Vol. 13, No. 17, February 1, 1950, pp. 11, 12.

New Aids for Australia's Air Traffic. Don Anderson. *Aircraft*, Vol. 28, No. 2, November, 1949, pp. 26, 27, 50, 52, 54, illus.

Hazards of Vehicular Operation on Airports. Jerome Lederer. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 20, 105, 106, illus.

Progress Report on London Airport. *The Aeroplane*, Vol. 77, No. 2012, December 30, 1949, pp. 873–877, illus., diagrs.

Air Transportation (41)

Postwar International Route Planning by the Civil Aeronautics Board. Edward C. Sweeney. *Journal of Air Law and Commerce*, Vol. 16, No. 4, Autumn, 1949, pp. 388–394.

The Feeder Airline Story. James G. Ray. *Journal of Air Law and Commerce*, Vol. 16, No. 4, Autumn, 1949, pp. 379–387.

How is Air Coach Working Out? Charles Adams. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, pp. 43, 44.

Low Fares or Luxury? E. P. Johnson. *The Aeroplane*, Vol. 78, No. 2013, January 6, 1950, pp. 20–22, illus.

Record Postwar Year for Aircraft Industry in 1950; Industry Quickly Approaching All-Military Production with Efficiency Increasing and Reconversion Now Complete. Robert McLarren. *Automotive Industries*, Vol. 102, No. 2, January 15, 1950, pp. 36–38, 106, 108, 110.

Let's Look at Commercial Flying in Canada Today. John R. Baldwin. *Canadian Aviation*, Vol. 23, No. 1, January, 1950, pp. 26, 28, 30, 37–39, 41.

An Outline of Recent Developments in Italian Civil Aviation. G. M. Riggi. *Shell Aviation News*, No. 137, November, 1949, pp. 10, 11.

Indian Internal Airlines. R. Vaughan Fowler. *The Aeroplane*, Vol. 77, No. 2011, December 23, 1949, pp. 849, 850, illus.

Future of Aerial Topdressing. A. M. Prichard. *New Zealand Flying*, Vol. 3, No. 27, November 15, 1949, pp. 4, 5.

An Airplane for Agriculture. George E. Haddaway. *Southern Flight*, Vol. 33, No. 1, January, 1950, pp. 15, 16, illus.

Outline of the probable specifications for an airplane being developed at the Personal Aircraft Research Center of the Agricultural & Mechanical College of Texas, specifically for farm use.

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Aviation Medicine (19)

Kinematic Behavior of the Human Body During Crash Deceleration. E. R. Dye. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 261* (Sherman M. Fairchild Publication). 11 pp., illus., figs. Members, $0.35, Nonmembers, $0.75.

In order to study head injuries and their causes, a mannikin constructed of aluminum sheet at full-scale dimensions and with pivots representing the major body joints, but of 1/20-scale weight, was built to simulate the human form in impact tests in a simulated cockpit that could produce acceleration and deceleration forces like those in an airplane crash. The cockpit device is accelerated along rails by stretched aircraft elastic shock cords. It has adjustable seat straps, and instruments to measure time, distance, acceleration, and impact forces. Results indicate that the seat strap does not appreciably change the impact velocity of the head, but it does reduce the energy of the blow, which is lightest when the strap angle is approximately 60° downward from horizontal and allows a hip movement of three to four inches. Impact energy of the blow to the head is increased by raising the arm to protect the face, because that motion increases the mass moment of inertia about the hip axis. When using the seat strap alone, the safest position for the head is pressed forward tightly against the instrument panel and cushioned by the forearm. An average man, aided only by the seat strap and his own back muscles, cannot prevent an impact blow to the head during decelerations greater than about 4.8 g.

The Airline Tryout of the Standard Flight-Check for the Airline Transport Rating. John A. Nagay. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 88*, December, 1949. 111 pp., diagrs. 3 references.

Direct comparisons of the new Objective Standard Flight-Check with the Civil Aeronautics Administration Flight-Test Report, Form ACA, 342A.

Sound Problems Resulting from Jet-Engine Operations. Donald H. Eldridge, Jr., Henry F. Koster, and Horace O. Parrack. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest*, Vol. 15, No. 2, February 1, 1950, pp. 19–21, figs.

Some Comments on the Presentation of Flight Information in the Cockpit of a Transport Aircraft with Particular Reference to Airborne Radar. R. W. Ayer. *American Airlines System, Flight Engineering, Operational Development Branch, Navy BuAer Contract NOa(s)-9006, Task No. 5, Final Report.* September 15, 1949. 4 pp.

Radar scopes of greater brilliance and contrast are the most urgently needed and when they become available should be mounted on the regular instrument panel, one for each pilot, with controls operable by either or both. Polaroid or other filters for the cockpit windows are desirable for improving scope visibility. "Closed circuit" warning lights to indicate the range being viewed are essential. The ground return line or altitude circle is of minor usefulness and gives accuracy of altitude information within about 5 per cent. In general, the present instrument-panel array is satisfactory.

The Effects of Polaroid and Blue Plastic to Provide Readable Radar Scope Under Daylight Conditions. *American Airlines System, Flight Engineering, ANTC Branch, Technical Note No. 6*, July 29, 1948. 6 pp.

Polaroid material, attached to cockpit windows and used as an overlay on the scope face, appears to be more effective in improving scope readability and cockpit visibility than combinations of blue and amber plastic materials.

The Factors in Human Vision Applicable to Photogrammetry. M. H. Salzman. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 637–647, figs. 27 references.

Medical Aspects of "Operation Vittles." Richard D. Nauman. *Contact*, Vol. 7, No. 2, July, 1949, pp. 21–24.

Comfortization (23)

The Stratos Story. *The Pegasus*, Vol. 15, No. 1, January, 1950, pp. 11–14, illus., diagrs. Air conditioning systems developed by the Stratos Corporation.

Designing Aircraft Interiors. W. D. Teague. *Indian Skyways*, Vol. 3, No. 7, July, 1949, pp. 25–29.

Testing Airplane Cabin Superchargers; Extensive Instrumentation Used for Automatic Tests Under Simulated Flight Conditions. J. Van Den Ende. *Instrumentation*, Vol. 4, No. 3, Fourth Quarter, 1949, pp. 10–12, illus., diagr.

Education & Training (38)

Efficient Teaching Methods Will Produce Better Pilots. II. Arnold Warren. *Canadian Aviation*, Vol. 23, No. 1, January, 1950, pp. 34, 36, 46, 56, illus.

New Low-Cost Navigation Trainer; Link Offers Electronic Device Designed to Train Pilots in Procedures Outlined in ANDB's Facilities Program. *Aviation Week*, Vol. 52, No. 5, January 30, 1950, p. 35, illus.

Cheaper Way to Train Jet Pilots (Linktronic). *Aviation Week*, Vol. 52, No. 4, January 23, 1950, pp. 32–34, illus.

Electronics (3)

Description of Circuitry for Erasing Video Signals Above a Selected Threshold Level and a Flap Attenuator for Automatically Measuring Its Performance When Connected to the Output of an Airborne Radar. *American Airlines System, Flight Engineering, Operational Development Branch, Technical Note No. 12*, May 23, 1949. 24 pp., illus., figs.

Miscellaneous By-Products Resulting from the Airborne Radar Contract Work. R. W. Ayer. *American Airlines System, Flight Engineering, Operational Development Branch, Final Report (Miscellaneous Items)*, September 15, 1949. 4 pp.

Impedance/Frequency Characteristics of some Slot Aerials. J. W. Crompton. *Institution of Electrical Engineers (London), Proceedings, Part III, Radio and Communcation Engineering*, Vol. 97, No. 45, January, 1950, pp. 39–44, diagrs., figs. 4 references.

A Discussion of the Effect of Nose Radomes on the H-Plane APS-10 Radiation Patterns and on the Usability of the "Safety Circle." *American Airlines System, Flight Engineering, ANTC Branch, Technical Note No. 1*, September 24, 1947. 8 pp., illus., figs.

Flight and service tests of the APS-10 radar installed in the nose of a DC-4-R5D airplane indicate the superiority of a radome of Fiberglas honeycomb sandwich construction with average transmissivity of 95 per cent or better. The radome causes very little distortion of the pencil beam, very little increase in the side lobes downward, and, therefore, almost negligible effect upon the safety circle scanned by the radar.

A Bushing Design for High Altitudes. F. J. Vogel and H. A. Hart. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 107, figs. (Extended summary of a paper: A Small High-Voltage Bushing Design for High Altitudes.)

Altitude Brings Avionics Challenge; Increasing Difficulties Will Beset Electrical Systems as Operating Levels Are Boosted. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, pp. 28, 30–32, figs. 11 references.

Magnetic Amplifiers. H. J. Smith. *Cornell Aeronautical Laboratory, Report No. UA-514-P-1*, August 23, 1949. 71 pp., diagrs., figs. 36 references. Explanation for engineers of the principles, circuits and methods of application of the magnetic amplifier as an electrical system worthy of development as an entity.

Aircraft Radio. James Holahan. *Radio & Television News*, Vol. 43, No. 1, January, 1950, pp. 31–34, 106, 107, illus., diagrs.

Equipment

ELECTRICAL (16)

Lightweight Aircraft Transformers. D. S. Stephens. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 156, illus., fig. (Extended summary of a paper.)

HYDRAULIC & PNEUMATIC (20)

Notes on Pneumatics. I. Eugene Stolarik. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 45–49, figs. 7 references.

Formulas and charts provide information for calculating the flow of compressed air through circular and rectangular orifices

and through capillary tubes as functions of pressure, temperature, and physical dimensions. Pneumatic variable resistances were designed and tested to determine the exact relationship of pressure drop or pressure changes and the corresponding flow. The investigation covers dimensional ranges of 0.001 to 0.1 in. and temperature-pressure effects ranging from −50° to 100°C. and from 2 to 30 lbs. per sq. in.

Auxiliary Power for Large, Turbine-Powered Aircraft. H. J. Wood and F. Dallenbach. *SAE Journal*, Vol. 58, No. 1, January, 1950, pp. 67–70, illus., diagrs. (Extended summary of a paper: Auxiliary Gas Turbines for Pneumatic Power in Aircraft Applications.)

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Notes on Some Charge Heating Anti-Icing Tests with an Axial Flow Turbo-Jet. J. J. Samolewicz and G. A. Macaulay. *Canada, National Research Council, Division of Mechanical Engineering, Engine Laboratory, Report No. ME-173*, December 31, 1948. 52 pp., illus., diagrs., figs. 4 references.

Water sprayed through a duct, with and without the addition of heat, was mixed with the charge air led to the compressor inlet of a Jumo 004 engine, at a temperature of about −7°C. Without added heat, ice formed within 5 min. on the starter dome and guide vanes, the thrust fell 84 lbs., and the exhaust temperature rose 40°C. Gradual additions of heat aggregating about 30°C. resulted in smaller ice formations, thrust losses of about 95 lbs., or 10 per cent, and an increase of 90°C. in the exhaust temperature. Heat additions amounting to about double the calculated theoretical values were required to prevent icing of the guide vanes, but were not sufficient to prevent ice formation on the starter dome, even when excessive heat was applied, and the ice accretion forced a shutdown terminating the experiment. In the investigation without heating it appears that the heavy ice accretion on the starter dome is associated with large water droplets, while icing of the guide vanes seems to be associated with smaller droplets.

Report on Instruments for Measuring Atmospheric Factors Related to Ice Formation on Airplanes. II. D. M. Patterson. *U.S., Air Force, Technical Report No. 5727 (ATI No. 38701)*, October 18, 1948. 74 pp., illus., diagrs., figs. 4 references.

Icing-Protection Requirements for Reciprocating-Engine Induction Systems. Willard D. Coles, Vern G. Rollin, and Donald R. Mulholland. *U.S., N.A.C.A., Technical Note No. 1993*, December, 1949. 61 pp., illus., diagrs., figs. 29 references.

An Electric Deicing System for Aircraft. E. W. Giloy. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 150, illus., diagr. (Extended summary of a paper.)

PILOTING TECHNIQUE

Development of an Airborne Radar Method of Avoiding Collisions with Terrain, Aircraft and Other Obstacles. R. W. Ayer and F. C. White. *American Airlines System, Flight Engineering, Operational Development Branch, Navy BuAer Contract NOa(s)-9006, Task No. 2, Final Report*, September 15, 1949. 19 pp., illus., figs.

Operational tests to determine the usefulness of pilot-operated radar as a warning device against collisions with mountains or other aircraft in flight and to determine the degree of pilot attention required. An X-band air-borne radar, scanning horizontally in the forward sector, stabilized in roll but not in pitch, and utilizing a "pencil" beam scan provides useful information and has "fail-safe" qualities that recommend it for emergency use. The echo caused by terrain targets and that caused by precipitation can be distinguished in two ways, the first and simpler of which is to raise the tilt of the beam above the horizontal when at altitude equal to or greater than the suspected terrain; if the echo disappears it is terrain. The second and more positive method involves a switchable circular-to-horizontal polarizing antenna feed; if the echo is greatly attenuated or disappears with the circularly polarized signal or remains in view under horizontal polarization, it is precipitation. If it remains in view without attenuation under either direction of polarization, the echo is "rock" or other objects to be avoided. The device has only relatively minor usefulness for aircraft collision warning because it is ineffective against flight paths converging from above or below, and is of only marginal use against other aircraft in level flight at approximately equal altitudes. Increased power from 15 kw. to 40 kw. or more should broaden the usefulness in both terrain and aircraft collision avoidance.

REFUELING IN FLIGHT

A New Method of Fuelling in Flight. *Shell Aviation News*, No. 137, November, 1949, p. 8, illus.

WEATHER HAZARDS

The Development of an Airborne Radar Method of Avoiding Severe Turbulence and Heavy Precipitation in the Precipitation Areas of Thunderstorms and Line Squalls. R. W. Ayer, F. C. White, and L. W. Armstrong. *American Airlines System, Flight Engineering, Operational Development Branch, Navy BuAer Contract NOa(s)-9006, Task No. 1, Final Report.* 50 pp., illus., figs. 12 references.

Test flights through thunderstorm clouds and areas of moderate and heavy precipitation, using a special form of 3.2 cm. airborne radar, gave preliminary proof that the most frequent, and probably the heaviest gusts, occur in areas of maximum rainfall gradient. Such areas are found and avoided by watching variations in the width of the doughnut rings on the radar scope. Hail of nondamaging size, up to $^3/_4$ in., was found with other forms of precipitation in practically all of the active thunderstorms probed, and it is probable that heavier hail likely to cause damage is prevalent in the area within the isoecho contour.

Hail Damage to Simulated DC-6 and Convair Leading Edges Under Laboratory Conditions and Development of a Suitable Hail Catcher. *American Airlines System, Flight Engineering, Operational Development Branch, Technical Note No. 10*, May 3, 1949. 17 pp., illus., figs.

In order to determine the flying speeds at which hail damage begins and to determine the size of hailstones causing damage, sections simulating the outer wing panel leading edges of transport airplanes were tested by firing hailstones of $^3/_4$ in., $1^1/_4$ in. and 2 in. diameter from air guns mounted 6 ft. from the sections, at speeds ranging from 110 to 460 m.p.h. Each hailstone struck a different point on the test section. Damage to the 0.040 in. 75S-T Alclad skin simulating the DC-6 wing panel began at an impact speed of 290 m.p.h. with the $^3/_4$ in. hailstones, and the first measurable dent in the 0.045 in. 24S-T section simulating the Convair panel was made at 206 m.p.h., but those dents were not considered large enough to require replacement. Indentations greater than 0.040 to 0.050 in. were considered significant and these appeared at speeds ranging from 250–260 m.p.h. for the $^3/_4$ in. ball to 105–115 m.p.h. for the 2 in. ball in the 24S-T, and from 375–395 m.p.h. to 160–175 m.p.h., respectively, in the 75S-T panel. Several methods were tried for catching hailstones in flight, the most successful of which involved a wooden box filled with upholsterers' cotton in which hailstones of all sizes were recovered unbroken after impact at 180 to 230 m.p.h.

Lightning Stroke Damage to Aircraft. J. H. Hagenguth. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 148, illus. (Extended summary of a paper.)

Flight Safety & Rescue (15)

Progress in Fire Prevention Following Crash. Lewis A. Rodert. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 265* (Sherman M. Fairchild Publication). 6 pp. 1 reference. Members, $0.35, Nonmembers, $0.75.

The solution of the airplane fire problem will be found in a reduction in the inflammability of materials; improved reliability of the engine, exhaust system, plumbing equipment, and fuel storage; and in detail and layout design to ensure maximum separation of inflammable materials from potential ignition sources. The combined efforts of research and industry groups should be focused on the problems of human endurance, limits of safety, versatility, and other factors that affect aircraft operating efficiency. Simplicity, safety, reliability, and comfort, as well as performance, enter into the economic equation of both military and commercial aviation. The ultimate objective of fire-prevention research should be the reduction of the fire problem to a level where industry, the traveling public, and the military services no longer have cause for serious apprehension from the fire hazard.

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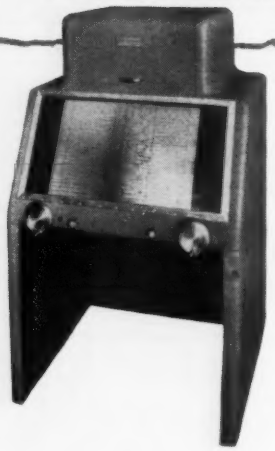

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Smoke Detector Value Weighed. Charles Adams. *Aviation Week*, Vol. 52, No. 4, January 23, 1950, pp. 43, 44, illus.

The Establishment and Measurement of Critical Requirements for Safe Flight in Transport Aircraft. Thomas Gordon. *Aeronautical Engineering Review*, Vol. 9, No. 1, January, 1950, pp. 22–24, fig.

Fuels & Lubricants (12)

Estimation of F-3 and F-6 Knock-Limited Performance Ratings for Ternary and Quaternary Blends Containing Triptane or Other High-Antiknock Aviation-Fuel Blending Agents. Henry C. Barnett. *U.S., N.A.C.A., Report No. 904*, 1948. 24 pp., figs. 5 references. U.S. Govt. Printing Office, Washington. $0.20.

A General Combustion Diagram Applicable to Any Fuel. M. Vernon. (*Revue Universelle des Mines*, 9th Series, Vol. 5, No. 5, May, 1949, pp. 150–170.) *The Engineers' Digest*, Vol. 11, No. 1, January, 1950, pp. 18–22, diagrs.

Knock-Limited Performance of Fuel Blends Containing Aromatics VI—10 Alkylbenzenes. I. L. Drell and H. E. Alquist. *U.S., N.A.C.A., Technical Note No. 1994*, December, 1949. 55 pp., figs. 8 references.

The Oxidation, Ignition, and Detonation of Fuel Vapors and Gases. XII—The High Compression Ratio Otto Cycle Gas Engine and the Adverse Effect of High Jacket Temperatures on Thermal Efficiency. R. O. King, Edwin J. Durand, and J. Alex. Morrison. *Canadian Journal of Research, Section F, Technology*, Vol. 27, No. 11, November, 1949, pp. 435–449, figs. 8 references.

Pathfinding in Fuels and Engines. T. A. Boyd. *S.A.E. Annual Meeting, Detroit, January 11, 1950.* 18 pp. 62 references. (Preprint.)

Gliders (35)

A Comparison Between Two Similar High Performance Sailplanes; The "Weihe" and the "Air 100." Guy Borgé. *Sailplane and Glider*, Vol. 17, No. 12, December, 1949, pp. 266, 267, illus.

35 Hours Aloft; An International Record Flight. Marcelle Choisnet. *Soaring*, Vol. 13, Nos. 9, 10, September-October, 1949, pp. 9, 12, illus.

A Trimmer for Intermediate Types. Peter Fletcher. *Sailplane and Glider*, Vol. 17, No. 12, December, 1949, p. 276, diagr.

Tour of New Zealand with the "Yellow Witch" "Olympia" Sailplane. Arthur D. Hardinge. *Sailplane and Glider*, Vol. 17, No. 12, December, 1949, pp. 271–275, illus.

Guided Missiles (1)

The Research Scene. III. Kenneth W. Gatland. *British Interplanetary Society, Journal*, Vol. 8, No. 6, November, 1949, pp. 231–238, illus., fig.

Brief report on recent rocket developments, including a circumlunar space craft described by the Pacific Rocket Society, the Aerobee rocket developed by Aerojet Engineering Corporation and Douglas Aircraft Company, Inc., the U.S. Navy's Viking rocket, a temperature recorder under development at the Illinois Institute of Technology, the Consolidated-Vultee "Lark" missile, the deHavilland Sprite assisted-take-off unit, a Ministry of Supply ground-to-air missile, Swedish guided missiles, and rocket progress in the Soviet Union.

A Note on the Approximate Plane Motion During the Burning Period of Rocket-Propelled Missiles Launched at Small Angles of Yaw from Aircraft. Ray E. Bolz. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, pp. 114–120, figs. 1 reference.

Instruments

AIRCRAFT (9)

Setrvačník se Dvěma Stupni Volnosti S Pružnou Hřídelí a Jeho Užití V Registračním Přístroji Úhlové Rychlosti (Gyroscope with Two Degrees of Freedom and with Elastic Shaft and Its Use in the Recording Instrument of Angular Velocity). T. Duda. *Prague, Letecký Výzkumný Ústav* (*Aeronautical Research Insti-*

tute), *Zpráva Č. 3*, 1947. 107 pp., illus., diagrs., figs. (In Czech with English summary.)

An elastic shaft used in gyro instruments of two degrees of freedom is subject to distortion under the influence of the accelerating forces and moments of aircraft movements, and such elasticity can cause errors in the readings of the instruments. To correct those errors an equation was derived from the inclination of the instrument frame, the moments of inertia, bending, and momentum, the angular velocity and constants representing control springs and damping cylinders. The theoretical treatment was confirmed by the use of apparatus consisting essentially of two counter-rotating gyroscopes having equal moments of momentum, parallel axes, and mutually interconnected frames, and by experiments on a turntable giving constant angular velocity. From the records of free and forced oscillations, it was possible to evaluate the frequencies and damping of the main free oscillation of the instrument, and good agreement with the theoretical calculation was found. The influence of atmospheric pressure on the indications of the instrument was considerable, amounting to an error of about 10 per cent at an altitude of 4,000 meters, for which allowance should be made. Temperature influences the damping constants, but corrections cannot be made in calculations by means of the equation and should be allowed for in the construction of the instrument.

Měření Polohových Uhlů Letadla Gyroskopickými Polohoměry. (Measurement of the Position Angles of the Aeroplane by Means of Gyro Horizon). Vilem Kicka. *Prague, Letecký Výzkumný Ústav (Aeronautical Research Institute), Zpráva Č. 5*, 1948. 6 pp., figs. 6 references. (In Czech with English abstract.)

A comparison of the performance characteristics of the Sperry gyro horizon instrument with those of the Alkan flight indicator.

Aircraft Radio Altimeters. B. A. Sharpe. *Institute of Navigation, Journal*, Vol. 3, No. 1, January, 1950, pp. 79–89, illus., diagrs., figs. 1 reference.

TEST & MEASURING

A Shielded Hot-Wire Anemometer for Low Speeds. L. F. G. Simmons. *Journal of Scientific Instruments*, Vol. 26, No. 12, December, 1949, pp. 407–411, illus., diagrs., figs. 2 references.

A low-speed anemometer which comprises an electrically heated wire and a thermocouple contained in a double-bore silica tube.

Airfoil Pitometer. Melvin W. First and Leslie Silverman. *Industrial and Engineering Chemistry*, Vol. 42, No. 2, February, 1950, pp. 301–308, illus., diagr., figs. 16 references.

An airfoil pitometer for simultaneous measurement of flow direction, velocity, and static pressure and its performance in turbulent and streamlined flow is presented. Its size and sensitive angle-of-flow-indicating characteristics make it suitable for measuring point conditions in curved flow streams encountered in elbows or cyclone dust collectors. The small, double-chamber type of airfoil pitometer has theoretical as well as experimental advantages over any existing type that has been previously described.

Heat-Conduction Errors in Temperature Measurements. L. E. Smith. *American Society of Mechanical Engineers, Transactions*, Vol. 72, No. 1, January, 1950, pp. 71–76, diagrs., figs. 5 references.

An Optical Pyrometer Employing an Image-Converter Tube for Use Over the Temperature Range 350–800 °C. C. R. Barber and E. C. Pyatt. *Journal of Scientific Instruments*, Vol. 27, No. 1, January, 1950, pp. 4–6, illus., diagr., figs. 3 references.

Design and Application of Thermocouples for Specific Needs. C. R. Bingham and C. C. Roberts. *Instrumentation*, Vol. 4, No. 3, Fourth Quarter, 1949, pp. 25–27, diagrs.

Investigation of a NACA High-Speed Strain-Gage Torquemeter. John J. Rebeske, Jr. *U.S., N.A.C.A., Technical Note No. 2003*, January, 1950. 41 pp., illus., diagrs., figs. 5 references.

Shaft Speeds and Vibrations Measured with Capacitance Pickup. Alvin B. Kaufman. *Machine Design*, Vol. 22, No. 1, January, 1950, pp. 87–89, illus.

An Apparatus for Measuring Small Changes in Linear Dimensions. D. G. R. Bonnell and A. Watson. *Journal of Scientific Instruments*, Vol. 27, No. 1, January, 1950, pp. 10–12, illus., figs. 2 references.

Laws & Regulations (44)

Need for Revision and Amplification of the Warsaw Convention. K. M. Beaumont. *Journal of Air Law and Commerce*, Vol. 16, No. 4, Autumn, 1949, pp. 395–413.

The Problems of Reasonable Rates. H. M. Nolan. *Indian Skyways*, Vol. 3, No. 7, July, 1949, pp. 11–15, illus.

The Regulation of Irregular Air Carriers; A History. Victor S. Netterville. *Journal of Air Law and Commerce*, Vol. 16, No. 4, Autumn, 1949, pp. 414–444.

Limitation of Passenger Liability Through Air Tariffs. R. G. Kahn. *Journal of Air Law and Commerce*, Vol. 16, No. 4, Autumn, 1949, pp. 482–490.

La Legislacion Aeronautica en Cuba (Aeronautical Legislation in Cuba). Alberto Castellanos. *Revista Aerea Cubana*, Vol. 7, Nos. 5, 6, June, 1949, pp. 12, 28, illus.

Machine Elements (14)

AUTOMATIC CONTROL

An Analysis of Relay Servomechanisms. D. A. Kahn. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 155, figs. (Extended summary of a paper.)

BEARINGS

The Full Journal Bearing. A. Cameron and W. L. Wood. *Institution of Mechanical Engineers, Proceedings, Applied Mechanics*, Vol. 161, *War Emergency Publication No. 48*, 1949, pp. 59–72, figs. 17 references.

Solution of the Reynolds equation for bearings of infinite length, and the application of Southwell's relaxation methods to the numerical computation of finite bearings of diameter/length ratios of 4, 2, and 1, to permit the calculation of minimum thickness of lubricant film.

Rolling Contact Bearing Mounting Units. *Product Engineering*, Vol. 21, No. 1, January, 1950, pp. 124, 125, diagrs.

Construction and Characteristics of Low-Cost Ball Bearings. F. W. Recknagel. *Product Engineering*, Vol. 21, No. 1, January, 1950, pp. 106–112, illus., diagrs., figs.

FRICTION

On the Magnitude of the Mechanical Component of Solid Friction. C. D. Strang and C. R. Lewis. *Journal of Applied Physics*, Vol. 20, No. 12, December, 1949, pp. 1164–1167, diagrs., figs. 9 references.

An experiment was performed in order to determine the magnitude of that portion of dry, kinetic friction which is contributed by Coulomb friction, or the mechanical interlocking of surface irregularities. The results indicate that the work of the mechanical component of friction accounts for only a few per cent of the work of total measured friction.

GEARS & CAMS

Epicyclic Gear Efficiencies. R. H. Macmillan. *The Engineer*, Vol. 188, No. 4900, December 23, 1949, pp. 727, 728, figs. 3 references.

KINEMATICS OF MACHINERY

Kinematics of Intermittent Mechanisms. IV—The Three-Gear Drive. S. Rappaport. *Product Engineering*, Vol. 21, No. 1, January, 1950, pp. 120–123, illus., figs.

MECHANISMS & LINKAGES

Straight-Line Linkages. H. G. Conway. *Machine Design*, Vol. 22, No. 1, January, 1950, pp. 90–92, figs.

SPRINGS

Characteristics of Ring Springs. Tyler G. Hicks. *Product Engineering*, Vol. 21, No. 1, January, 1950, pp. 86–89, diagrs.

Maintenance (25)

Maintenance Organization and Management; A Case from Transportation. George E. Keck. *American Society of Mechanical Engineers and Society for the Advancement of Management, Joint Conference, Cleveland, Ohio, January 16, 1950.* 11 pp., figs. (Preprint.)

Douglas Service, Vol. 7, No. 6, November-December, 1949. 20 pp., diagrs.

Contents: Super DC-3 Structures, DC-35. Landing Gear Bolt and Bushing Wear Tolerances—For DC-3 and C-47 and DC-3S Airplanes, DC-3, C-47. Super DC-3 Station Diagrams, DC-3S. Engine Mount Repairs—General Repair Procedures for DC-3, C-47, C-54 and DC-6 Engine Mounts, General. C-47B Catalog Reprint, C-47B. Insulating Generator Leads, DC-6.

Boeing Service Guide, No. 27, December, 1949. 16 pp., illus., diagrs.

Contents: Water Injection System. Main Landing Gear Wheel Bearing Installation. Flexible Fuel Vent Installation. Antenna Mast Repair. Toilet Dump Valve Linkage Adjustment. Toilet Air Compressor Servicing. Checking and Applying Accumulator Preload Pressure. Cabin Heater Combustion Air Duct Installation. In-Flight Oil Transfer. Removal Precaution—Rudder Boost Hydraulic Panel. Effect of Cabin Pressurization on Engine Life and Fuel Consumption. Prevent Hydraulic Line Damage. Stratocruiser Decompression Provisions.

Materials (8)

METALS & ALLOYS

Directionality of Wrought Light Alloy Materials. I. L. G. Baillie. *Royal Aeronautical Society, Journal,* Vol. 54, No. 469, January, 1950, pp. 11–18, illus., figs.

Tubes, sheets, extrusion, and forgings of medium-strength and high-strength wrought light alloy materials have inherent and distinctive mechanical properties that vary with the crystal grain direction. In tubes the grains are elongated in the direction of the longitudinal axis of the tubes. Since tubes are generally employed in direct tension, compression, or torsion, sometimes combined with bending, and since those stresses do not result in primary transverse tension, the conventional stressing methods automatically include the effects of directionality. Comparison of tensile and compressive test results on coiled sheets, trimmed strip, and rolled sheets represented by 270 specimens extracted longitudinally and 54 specimens extracted transversely in relation to the principal axis of rolling, indicated no serious directionality effect. The ratio of transverse to longitudinal properties averaged 0.96 for proof stress and 0.99 for ultimate stress. No significant difference was noted in elongation values in the two directions. Specimens of extruded bars numbering 120 showed a mean ratio of 0.75 transverse to longitudinal for proof and ultimate tensile stress, and of about 0.44 for ultimate elongation. Other specifications gave about 0.77 for tensile and 0.11 for elongation. In large extrusions the ratio remains approximately constant throughout the cross section. Tests on 238 specimens of die forgings having various primary grain directions gave transverse to longitudinal tensile ratios over 0.90 in all but one case, but ultimate elongation results ranged from 0.92 to 0.07. Forging and heat-treatment processes can cause a drop in strength of about 10 per cent for tensile and 60 per cent for longitudinal elongation. Hand forgings give approximately the same results as die forgings. Analyses of several unpredicted failures of aircraft parts show the influences of directionality and indicate what steps should be taken in design to avoid premature failure.

Reinforced Light Alloys. E. H. Kinelski. *Cornell Aeronautical Laboratory, Inc., Internal Project, Final Report No. KB-412-M-1,* August 15, 1949. 10 pp., illus., figs., diagrs. 2 references.

Various attempts were made to produce a steel-reinforced aluminum that would have a favorable strength-weight ratio, by casting aluminum around steel wire and by brazing a sandwich of aluminum strips with steel wires. Stainless W wire, with and without zinc coating, was run through baths of molten 75S aluminum at 1,300°F. for 15 to 30 sec. The bare wire showed no metallic bond with the aluminum, but the zinc-coated wire did make a bond although its ultimate load and tensile strength were greatly reduced. Rolling the wire in 75S aluminum failed because the wire broke in the rolling process. Casting low-carbon steel strips with aluminum failed when the aluminum peeled off. A single-lap tensile shear specimen of 61S aluminum sheet without wires, brazed in a furnace at 1,075°F. for seven minutes failed in shear at 606 lbs. per sq.in., and no bond was obtained in brazing a sandwich of 61S aluminum and Stainless W wire. Thicker aluminum brazing sheet failed to bond because the wires separated the aluminum strips.

Effect of Carbon in Titanium Metal Ingots. E. A. Gee, J. B. Sutton, and W. J. Barth. *Industrial and Engineering Chemistry,* Vol. 42, No. 2, February, 1950, pp. 243–249, illus., figs. 4 references. (Titanium Symposium.)

Preparation and Properties of Titanium-Base Alloys. P. H. Brace, W. J. Hurford, and T. H. Gray. *Industrial and Engineering Chemistry,* Vol. 42, No. 2, February, 1950, pp. 227–236, illus., diagrs., figs. 1 reference. (Titanium Symposium.)

Titanium Alloys. Bruce W. Gonser. *Industrial and Engineering Chemistry,* Vol. 42, No. 2, February, 1950, pp. 222–226, figs. 20 references. (Titanium Symposium.)

Potential Uses of Titanium Metal. O. C. Ralston and F. J. Cservenyak. *Industrial and Engineering Chemistry,* Vol. 42, No. 2, February, 1950, pp. 214–218, illus. 30 references. (Titanium Symposium.)

Magnesium in Navy Planes. J. E. Sullivan. *Aero Digest,* Vol. 60, No. 1, January, 1950, pp. 78, 80, 91, 93, illus. (Extended summary of a paper.)

Influence of Stress Concentration, Speed of Deformation, and Temperature on the Rupturing Strength of Steels. A. Gueussier and R. Castro. (*Revue de Metallurgie,* Vol. 46, No. 8, August, 1949, pp. 517–536.) *The Engineers' Digest,* Vol. 10, No. 12, December, 1949, pp. 412–414, figs. 4 references.

Austenitic and Special Stainless Steels. II. Samuel J. Rosenberg. *Product Engineering,* Vol. 21, No. 1, January, 1950, pp. 113–117, illus., figs.

The Seizure of Metals. F. P. Bowden and D. Tabor. *Institution of Mechanical Engineers, Journal & Proceedings,* Vol. 160, No. 3, December, 1949, pp. 380–383, illus., figs.

How Plastic Deformation Influences Design and Forming of Metal Parts. II—Plastic Flow and Rupture of Metals. John R. Low, Jr. *Materials & Methods,* Vol. 30, No. 6, December, 1949, pp. 59–63, diagrs., figs.

Investigation of Purity of Aluminum-Silicon Die Casting Alloys. Donald L. Colwell. *American Society for Testing Materials, Bulletin,* No. 163, January, 1950, pp. 51–53, figs. 7 references.

Causes of Corrosion in Airplanes and Methods of Prevention. N. H. Simpson. *Corrosion,* Vol. 6, No. 2, February, 1950, pp. 51–57, illus., figs. 4 references.

NONMETALLIC MATERIALS

Use of Plastics in Aircraft. Low-Pressure Plastic Laminates, by W. G. Ramke. **Transparent Materials for Aircraft Glazing,** by W. R. Koch. **Electrical and Electronic Application of Plastics,** by F. H. Behrens. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 15, No. 1, January 1, 1950, pp. 15–23, illus., figs.

Plastics Research Accelerated; Increasing Aircraft Performance Brings New Demands on Characteristics for Transparent Enclosures. *Aviation Week,* Vol. 52, No. 4, January 23, 1950, pp. 26, 31.

Synthetic Resin Adhesives for the Woodworking Industries; A Glossary of Terms. *Aero Research, Ltd., Technical Notes, Bulletin No. 84,* December, 1949. 11 pp.

Structural Metal Adhesives for Aircraft. D. A. Shinn. *U.S., Central Air Documents Office (Navy-Air Force), Technical Data Digest,* Vol. 15, No. 2, February 1, 1950, pp. 16–18, illus. 16 references.

Silicone Putty as an Engineering Material. Laurence W. Spooner. *Product Engineering,* Vol. 21, No. 1, January, 1950, pp. 90–93, diagrs., figs.

The rheological properties of silicone putty or "bouncing putty" indicate its usefulness in shock absorbing, vibration damping, pressure equalizing, and leveling devices. Flow characteristics of this semiplastic material have been studied in detail.

Meteorology (30)

Artificial Nucleation of Clouds. Ronald Frith. *The Meteorological Magazine*, Vol. 79, No. 931, January, 1950, pp. 5–9. 4 references.

Review of recent accomplishments in stimulation and control of precipitation, and a report on experiments made during the past two years by the Meteorological Research Flight in England.

Analysis of Experiments on Inducing Precipitation. J. L. Orr, D. Fraser, and K. G. Pettit. *Canada, National Research Council, Division of Mechanical Engineering, Low Temperature Laboratory, Report No. MD-32*, August 17, 1949. 27 pp., illus., figs. 8 references.

Precipitation reached the ground in 43 per cent of the cases where supercooled cumulus clouds were inoculated with dry ice, and in 24 per cent of the cases where clouds were selected at random. These results are comparable with similar trials in Australia and demonstrate the practicability of the method under favorable conditions.

Comparación entre los Diagramas Termodinámicos de la Atmósfera, más Usados en Meteorología. Carmelo DiCorleto. (*La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Físicomatemáticas, Revista*, Vol. 3, No. 1, March 15, 1944, pp. 39–75.) *La Plata, Argentina, Universidad Nacional, Facultad de Ciencias Físicomatemáticas, Instituto de Aeronautica, Publicación No. 12*, 1944. 44 pp., figs. 16 references.

Artificial Stimulation of Rain. *The Meteorological Magazine*, Vol. 79, No. 931, January, 1950, pp. 9, 10. Brief report on experiments in the vicinity of Appleby, England, giving figures and a summary of the results obtained.

La Stabilité des Mouvements Atmospheriques (The Stability of Movements of the Atmosphere). Jacques van Mieghem. *Organisation Meteorologique International, Commission Aerologique, Toronto Session, Final Report (CAe. Document No. 71) Appendix No. 11*, August 22, 1947. 9 pp. 22 references. (Corrected Edition, 1948.) (In French.)

A Concise Method for Recording Synoptic Data. A. J. Whiten. *The Meteorological Magazine*, Vol. 79, No. 931, January, 1950, pp. 11, 12.

Cumulus, Thermals and Wind. Joanne Starr Malkus. *Soaring*, Vol. 13, Nos. 9, 10, September–October, 1949, pp. 6–8, 12, illus., figs.

Military Aviation (24)

Air Force Armament; Ordnance Makes the Airplane a Weapon. *Ordnance*, Vol. 34, No. 178, January–February, 1950, pp. 228, 229, illus.

Bombing Accuracy; Hitting Targets on the Nose is the Air Force's Goal. Philip Schwartz. *Ordnance*, Vol. 34, No. 178, January–February, 1950, pp. 230–233, illus.

The Protection of the Sea Routes in War. Norman Macmillan. *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 24–29, illus.

Red Stars in the Sky. *Interavia*, Vol. 4, No. 11, November, 1949, pp. 641–649, illus.

Estimates of the total strength, aircraft types, equipment, personnel, and top command of the Soviet air force, and of the industrial resources, production facilities, and educational progress of the U.S.S.R.

Navigation (29)

Position Line Protractor. *Aeronautics*, Vol. 22, No. 2, January, 1950, pp. 40, 41, fig.

A device for determining positions when the intercept may amount to 300 nautical miles or more, and the actual position may lie as much as 120 nautical miles to one side of the computed line of azimuth. It is constructed to the horizontal stereographic projection and can be used with maps based on the Lambert Conformal projection without serious error.

The Use of Two Decca Chains to Obtain Accurate Fixes at Long Ranges. A. R. Cottle. *Institute of Navigation, Journal (London)*, Vol. 3, No. 1, January, 1950, pp. 34–38, figs. 1 reference.

Amateur Navigation in Light Aircraft. Walter W. Zimmerman. *Navigation*, Vol. 2, No. 4, December, 1949, pp. 86–90, illus.

Navigation in High Speed Flight. E. W. Anderson. *Institute of Navigation (London), Journal*, Vol. 3, No. 1, January, 1950, pp. 61–78, figs.

A Simultaneous Two-Star Fix. Charles T. Dozier. *Navigation*, Vol. 2, No. 4, December, 1949, pp. 91, 92, fig.

Photography (26)

Parallax. A. R. Robbins. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 631–635, fig. A review of the correct methods of obtaining elevations from stereoscopic photographs by means of the differential parallax.

Explicit Three-Point Resection in Space. E. L. Merritt. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 649–665, figs.

Aerial Celestial Positioning of Ground Control Points for Arctic Mapping. Marvin Greenberg. *Institute of Navigation, Journal*, Vol. 2, No. 4, December, 1949, pp. 98, 99.

Graphical Interpolation-Adjustment of a "Double-Strip." Jerry Zarzycki. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 666–671, figs.

A Method of Finding Gradients from Air Photographs with No Control. A. R. Robbins. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 636, 637.

Airphoto Interpretation of Engineering Sites and Materials. Jean E. Hittle. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 589–603, illus. 7 references.

Petroleum Photogeology. A. R. Wasem. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 579–589, figs.

Aerial Photographs and the Soil Conservation Service. Edward W. Margruder. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 517–536, illus.

Trends and Needs in Photogeology and Photo-Interpretation—Discussion Forum. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 567–578.

Air Photography and Its Application to Forestry. H. E. Seely. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 548–554. 6 references.

Practical Application of Photogrammetry in Land Classification as Used by the Bureau of Land Management. Douglas E. Henriques. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 540–545.

Use of Aerial Photographs in Connection with Farm Programs Administered by the Production and Marketing Administration, U.S.D.A. Ralph H. Moyer. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 536–540.

Forest Service Use of Aerial Photographs. Raymond D. Garver and Karl E. Moessner. *Photogrammetric Engineering*, Vol. 15, No. 4, December, 1949, pp. 504–516, figs.

Power Plants

Peut-on Associer Avantageusement Moteurs Alternatifs et Propulsion par Reaction? M. Serruys. *Technique et Science Aéronautiques*, No. 5, 1949, pp. 279–297, diagrs.

Évolution Passée et Future des Engins Propulsifs. Maurice Roy. *Technique et Science Aéronautiques*, No. 5, 1949, pp. 270–278, fig. 12 references.

JET & TURBINE (5)

Surging of Axial Compressors. H. Pearson and T. Bowmer. *The Aeronautical Quarterly (Royal Aeronautical Society, London)*, Vol. 1, Part 3, November, 1949, pp. 195–210, figs.

A treatment of the problem of surging in axial compressors by which the probable surge point of a compressor may be predicted, and which shows that, although the assumption that surging will occur on the peak of the characteristics cannot be justified on simple grounds, the surge point may coincide with the peak or may occur at even higher flows.

Causes and Control of Powerplant Surge. R. B. Pearce. *Aviation Week*, Vol. 52, No. 3, January 16, 1950, pp. 21–25, figs. 8 references.

Impeller Design for Centrifugal Pumps and Compressors. K. Pantell. (*Konstruktion*, Vol. 1, No. 3, 1949, pp. 77–82.) *The Engineers' Digest*, Vol. 10, No. 12, December, 1949, pp. 423–427, figs. 3 references.

Analysis of Effect of Basic Design Variables on Subsonic Axial-Flow-Compressor Performance. John T. Sinnette, Jr. *U.S., N.A.C.A., Report No. 901*, 1948. 21 pp., figs. 16 references. U.S. Govt. Printing Office, Washington. $0.20.

Study of Efficiency and Thrust of Conventional Turbo-Jet Propulsor. Boleslaw Szczeniowski. *Revue Trimestrielle Canadienne (Montreal)*, No. 139, Autumn, 1949. 27 pp., figs. 11 references. (In English.)

Special systems involving the use of heat recuperation or heat exchangers can be used to improve the thermal efficiency of turbojet engines, but the disadvantages usually outweigh the gains, because such apparatus is complicated and adds to the engine weight. Efficiency can be improved by raising the maximum temperature of the cycle, which at present is restricted to about 1,500°F. by the limitations of available metals. Utilization of higher temperatures will require further improvement in the metallurgy of super alloys. A second possible method of improving efficiency is by increasing the compression ratio of the turbocompressor unit, but that will entail an increase in the specific weight of the engine and may cause a decrease in the specific thrust obtainable, due to the greater air excess required by the temperature limitation. Since efficiency and compression ratio are dependent upon each other, there must be further improvement in both factors and higher compression and expansion ratios should be attained in a single stage in order to reduce the weight and bulk of the engine.

Turbojet Intake Configurations. I. A. W. Quick. *Interavia*, Vol. 4, No. 11, November, 1949, pp. 679–684, illus., diagrs., figs.

Mathematical computations of the drag of the air intake and the relationship of internal drag and thrust loss to the drag of the entire aircraft include formulas for calculating the effects of boundary-layer suction and external losses. At speeds approaching sonic values, compressibility shocks must be expected at the outer contour of the intake leading edge. Intakes can be located in the nose, or in the top, bottom, or side of the fuselage, at the wing root, in the wing leading edge, below the wing, in wing nacelles, or buried completely in a flying-wing configuration. Each arrangement has its advantages and drawbacks. Adjustable intake cross sections offer desirable compromises in design.

Design of Turboprop Transports. II—Gust Alleviation, Weight Analysis, Conclusion. *Flight*, Vol. 57, No. 2141, January 5, 1950, pp. 26, 27, figs. (Extended summary of a paper.)

Aircraft Turbines. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 82–85, illus.

Descriptive sketches covering design and construction details, performance, development history, type numbers used by manufacturers and military services, and information about the aircraft in which each engine is employed. Tabulated specifications also are given for American and British gas-turbine power plants.

Comparison of Various Methods of Thrust Augmentation for Turbojet Engines. Eldon W. Hall. *Aeronautical Engineering Review*, Vol. 9, No. 1, January, 1950, pp. 25–30, diagrs. 1 reference.

A Thermodynamic Study of the Turbojet Engine. Benjamin Pinkel and Irving M. Karp. *U.S., N.A.C.A., Report No. 891*, 1947. 29 pp., figs. 8 references. U.S. Govt. Printing Office, Washington. $0.20.

Readers' Forum: The Mechanism of Unstable Combustion. W. C. Randels. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, pp. 124, 125, figs. 1 reference.

Gas-Turbine Starter. *Aero Digest*, Vol. 60, No. 1, January, 1950, p. 50, diagr.

Cordite gas, contained in six cartridge barrels arranged in a circular cluster, flows through nozzles to counter-rotating turbine wheels whose speed of about 40,000 r.p.m. is reduced by gearing and is applied through a multiple-plate clutch to the rotor shaft of the gas turbine being started. The unit, complete with cartridges, weighs 50 lbs. and has maximum energy output of 50,000 ft. lbs.

A High-Speed, High-Temperature Precision Testing Machine for Gas Turbine Disk Research. A. C. Hagg, B. Cametti, and G. O. Sankey. *Westinghouse Research Laboratories, Scientific Paper No. 1461*, August 19, 1949. 28 pp., illus., diagrs., figs. 3 references.

A steel structure with suitable bearings supports a vertical flexible-shaft assembly at the top of which the specimen turbine

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disc is mounted in a fixture that, in turn, is installed in the center of an electric furnace. The disc is rotated by a variable-speed induction motor attached at the bottom of the shaft. Extensive equipment for control and measurement makes it possible to record rotation speeds, temperature changes, plastic flow, and creep strains occurring under the conditions of the tests conducted in conjunction with theoretical studies of the strength of gas-turbine discs, the objective of which is the development and evaluation of design calculation methods. The machine can handle disc specimens of diameter up to 14 in. and 2 in. thick, at speeds up to 35,000 r.p.m. and temperatures up to 1,500°F. of uniform intensity or in radial gradients up to about 100°F. per inch of specimen size. The equipment includes special thermocouple circuits, accurate speed controls, optical comparators, and other measuring devices permitting average speed errors less than 0.01 per cent, temperature errors less than 10°F., and strain measurement errors averaging 5 per cent.

Factors in Gas Turbine Blade Production. *Aviation Week*, Vol. 52, No. 3, January 16, 1950, pp. 27, 28, 33, 34, illus. (Extended summary of a paper: Blade Design and Production.)

Precision Testing of Gas Turbine Disks. *Automotive Industries*, Vol. 102, No. 2, January 15, 1950, pp. 40, 41, diagr., figs.

First in Canada; de Havilland Jet Overhaul Shop. *Aircraft and Airport*, Vol. 12, No. 1, January, 1950, pp. 7–9, illus., diagr.

Boeing Jet (502) Set for Market Tests. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, pp. 39, 40, illus.

Allison's New T-40 Turboprop. Paul H. Wilkenson. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 18, 94, illus.

TG-190 Jet Approved by CAA; First U.S. Axial-Flow Engine Certified for Commercial Plane Use Has Rating of 5000-Lb. Static Thrust. *Aviation Week*, Vol. 52, No. 3, January 16, 1950, p. 40.

Proteus Airscrew-Turbine; Features of Powerful Bristol Unit. *Modern Transport*, Vol. 62, No. 1607, January 14, 1950, p. 12.

Pre-Flight Trials; Extended Full-Scale Testing of Proteus Turboprops. *Flight*, Vol. 57, No. 2141, January 5, 1950, p. 25, illus.

Engine Assessment of the Mamba-Dakota. R. G. Worcester. *The Aeroplane*, Vol. 77, No. 2011, December 23, 1949, pp. 846–848, illus., diagr.

A Critical Review of Gas Turbine Progress. I. II. *The Engineer*, Vol. 189, Nos. 4902, 4903, January 6, 13, 1950, pp. 32, 33; 40, 41.

RECIPROCATING (6)

The Ideal Performance of Petrol Engines. A. S. Leah. *Institution of Mechanical Engineers, Proceedings, Internal Combustion Engine Group*, Vol. 161, *War Emergency Publication No. 49*, 1949, pp. 121–128, figs. 6 references.

Thermal data derived by quantum statistical methods from spectroscopic studies have made possible a method of calculating the ideal thermal efficiencies of piston engines when thermodynamic charts for the particular fuels and mixture strengths are not available. Results of such calculations are given for engines running on octane, benzine, and ethyl alcohol at compression ratios between 4:1 and 9:1 and at various mixture strengths. New charts based on the familiar "consumption loop" diagram are developed from the relationships between thermal efficiency, specific fuel consumption, volumetric efficiency, mixture strength, and indicated mean effective pressure. The ideal consumption loop diagrams based upon a standard volumetric efficiency are included on the charts, and those values are easily corrected to the actual engine conditions by a simple graphical construction. A direct comparison is thus made possible between actual and ideal engine performance.

Reciprocating Engines. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 86–88, 90, 92, illus.

Figures are tabulated for performance, dimensions, model numbers, weights, and other details of the power sections of the engines, and for specifications of the accessories, components, and equipment used.

Knocking Combustion Observed in a Spark-Ignition Engine with Simultaneous Direct and Schlieren High-Speed Motion Pictures and Pressure Records. Gordon E. Osterstrom. *U.S., N.A.C.A., Report No. 897*, 1948. 19 pp., illus., diagrs. 12 references. U.S. Govt. Printing Office, Washington. $0.20.

Studies of Combustion Kinetics. James T. Grey. *Cornell Aeronautical Laboratory, Inc., Internal Research Project No. RH-560-M-1, Final Report*, August 18, 1949. 15 pp., illus., diagrs. 5 references.

Since the pressure encountered in the combustion chambers of air-breathing jet missiles falls in the moderate-pressure domain, experimental studies were made of the effects of pressure on explosion flames by means of two burners in which the effective pressure was observed. A limited amount of spectroscopic work was directed to the evaluation of the effects of electrical fields on the chemical reactions that occur in the flames. In a single experiment, the previously reported distorting effect of an electrical field on a simple flame was verified.

Maintenance of the Pratt and Whitney Wasp Major Engine. *Shell Aviation News*, No. 137, November, 1949, pp. 14–16, illus., diagrs.

Overhaul Period Bristol Hercules 634. *Shell Aviation News*, No. 137, November, 1949, p. 24, fig.

Development of the Hercules Engine. *Indian Skyways*, Vol. 3, No. 2, November, 1949, pp. 44, 45, 47, fig.

ROCKET (4)

Rocket Power—Its Place in Aeronautics. Robert McLarren. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, pp. 21, 22, 24, 25, figs. 12 references.

Chemical Kinetics and Jet Propulsion. Fritz Zwicky. *Chemical and Engineering News*, Vol. 28, No. 3, January 16, 1950, pp. 156–158, illus.

"The Sprite"; The First de Havilland Rocket. *British Interplanetary Society, Journal*, Vol. 8, No. 6, November, 1949, pp. 229–231, illus.

Production (36)

Le Problème Général de la Production des Cellules. Jules Jarry. *Technique et Science Aéronautiques*, No. 5, 1949, pp. 252–269, illus.

Vickers-Supermarine Attacker. I—Naval Interceptor-Fighter in Production, Basic Manufacturing Processes, Fuselage Construction. S. C. Poulsen. *Aircraft Production*, Vol. 12, No. 135, January, 1950, pp. 11–18, illus., diagrs.

Large Pressure-Forgings; Their Significance for Military Aircraft, Existing and Proposed Manufacturing Facilities in the United States. K. B. Wolfe. *Aircraft Production*, Vol. 12, No. 135, January, 1950, pp. 23–26, illus. (Extended summary of a paper.)

Modern Wing Structures; The Importance of Tapered Sheet and Large Pressure-Forgings. S. Joseph Pipitone. *Aircraft Production*, Vol. 12, No. 135, January, 1950, pp. 27–32, illus., diagrs., figs. (Extended summary of a paper.)

Aircraft Built by Outside-In Jig Technique. Frederick R. Brewster. *Aviation Week*, Vol. 52, No. 5, January 30, 1950, pp. 27, 28, 30, illus.

Non-Metallic Dies for Aircraft Fabrication. John Delmonte. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 52, 53, 97, illus., fig. Summary of nonmetallic materials for dies and tools, giving properties, processing methods, and applications for which they are advantageous.

Envelope Tooling. *Aircraft Production*, Vol. 12, No. 135, January, 1950, pp. 3–6, illus.

The method of manufacture, which is based on the aerodynamic form of the aircraft, consists of building the component assemblies from the skin plating inward instead of first building the structural framework and then applying the skin. It involves the erection on a rigid base of a series of formers or templates shaped to the external contour, which is established at a predetermined distance outside the skin plating. Advantages are that work can start on templates as soon as the shape is established, and on the actual fixtures as soon as the subassembly breakdown has been settled.

Materials Engineering File Facts; Causes and Cures of Common Welding Problems. *Materials & Methods*, Vol. 30, No. 6, December, 1949, pp. 83, 85.

Non-Welds; The Investigation and Elimination of a Fault in the Resistance-Welding of Aluminium Alloy. G. W. Weeks. *Aircraft Production*, Vol. 12, No. 135, January, 1950, pp. 7–10, illus., diagrs.

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Welding of Aluminum Alloys; Value of Laboratory Tests. W. I. Pumphrey and D. C. Moore. *Institute of Welding, Transactions*, Vol. 12, No. 6, December, 1949, pp. 146–150, figs. 8 references. (Discussion of a paper.)

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Production Processes; Their Influence on Design. I—Investment Casting. Roger W. Bolz. *Machine Design*, Vol. 22, No. 1, January, 1950, pp. 93–99, 150, illus., diagrs.

The "Lost Wax" Process of Precision Casting. J. S. Turnbull. *The Engineer*, Vol. 189, No. 4904, January 20, 1950, pp. 97–99, illus. (Extended summary of a paper.)

Propellers (11)

Propellers. *Aviation Operations*, Vol. 13, No. 1, January, 1950, p. 93. Tabulated specifications of American propellers, giving the manufacturers' numbers, material, pitch, power range, control method, dimensions, equipment, and other data.

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The Spinner Returns. *The Bee-Hive*, Vol. 26, No. 1, January, 1950, pp. 9–11, illus.

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Rotating Wing Aircraft (34)

Design and Operational Features of the Sikorsky 1000 H.P. Helicopter Rotor Test Stand. H. T. Jensen. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 262* (Sherman M. Fairchild Publication). 15 pp., illus., diagrs., figs. 3 references. Members, $0.35, Nonmembers, $0.75.

The stand incorporates a steel-beam conical structure supporting a shaft mechanism at the top of which a helicopter rotor of any form can be mounted. A 1,000 hp. d.c. dynamometer with its equipment provides a speed range of 120 to 240 r.p.m. or 200 to 400 r.p.m. through shafts, bearings, reduction and bevel gears, and couplings, with suitable controls and instrumentation to measure thrust, torque, side force, blade moment, control moment, horsepower, and atmospheric data. Indications can be given for three blade angles, three lag angles, and three coning angles, or a combination of those angles for one blade, compared with time or azimuth. Tests have been completed on performance of main rotors, effect of wind velocity on rotor performance. Stroboscopic pictures of blade bending, fatigue testing of a main rotor assembly, a 1,000-hour endurance test of the S-51 rotor head and all-metal blades, and miscellaneous tests involving mechanical operation of rotating parts have also been conducted.

A Type of Lifting Rotor with Inherent Stability. Kurt H. Hohenemser. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 245* (Sherman M. Fairchild Publication). 19 pp., figs. 5 references. Members, $0.50, Nonmembers, $0.75.

The more important of the forward flight aerodynamic characteristics of a rotor are presented where the collective blade pitch angle is kinematically coupled with the collective flapping or coning angle, while no coupling is provided between cyclic flapping and cyclic pitch angles. The rotor with pitch-cone change may be designed to have positive static stability as compared to the negative static stability of the conventional fixed-pitch rotor; partial blade stall during pull-ups or upward gusts may be avoided in spite of a high and economic thrust coefficient in steady flight, and no adjustment of the collective pitch control is required for the transition from powered flight to autorotation.

A Proposed Method of Determining the Frequency Response of a Helicopter by Analysis of Recorded Transients. John O'Dea. *Cornell Aeronautical Laboratory, Inc., Flight Research Department, Report No. TG-587-F-1*, November 24, 1948. 46 pp., figs., diagrs. 6 references.

The frequency response and phase shift of a single-rotor helicopter, with gyroscopic stabilization, are obtained by analysis of a transient derived experimentally. The method is based on the determination of an analytical expression for the response of the helicopter to a unit impulse. Using the superposition theory (Duhamel's integral) the steady-state response to a sinusoidal forcing function can be formulated in terms of the parameters of the transient. By extracting those parameters from the experimental response by means of the analytical expression, the frequency response may be calculated from the extracted constants and the derived equation for the response to a sinusoidal function.

A Theoretical Analysis of Elastic Vibrations of Fixed-Ended and Hinged Helicopter Blades in Hovering and Vertical Flight. Morris Morduchow. *U.S., N.A.C.A., Technical Note No. 1999*, January, 1950. 61 pp., diagrs., figs. 10 references.

Helicopters: Their History, Development, Construction, Operation and Future. I. B. Laskowitz. *The Municipal Engineers of the City of New York, Journal*, Vol. 35, No. 4, 1949, pp. 105–120, illus., figs. 5 references.

Explanation of the design and operating principles of helicopters, specifications and estimates of operating costs, review of commercial and municipal utilization of helicopters, and a forecast of the broadening fields of service for that type of aircraft.

U.S. Helicopters. *Aviation Operations*, Vol. 13, No. 1, January, 1950, pp. 62, 63, illus. Tabulated specifications covering design and construction details, performance, and the manufacturers' and military services' type designations.

Rotary Wing Pictorial Review for 1949. *American Helicopter*, Vol. 17, No. 1, December, 1949, pp. 9–18, illus.

C-W Enters AF Helicopter Bid. *Aviation Week*, Vol. 52, No. 5, January 30, 1950, pp. 14, 15, illus. Curtiss-Wright Corporation, CW-40 Arctic Rescue Helicopter.

The Kaman K-190 Helicopter. *Aircraft and Airport*, Vol. 12, No. 1, January, 1950, pp. 11, 12, illus., diagrs.

Kaman Helicopter Has Ugly Duck Look but Flies Like a Dream. Ronald A. Keith. *Canadian Aviation*, Vol. 23, No. 1, January, 1950, pp. 40, 56, illus.

Sikorsky 12-Place Helicopter (H-19). *Aero Digest*, Vol. 60, No. 1, January, 1950, p. 58, illus.

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Reveal Details on Transport Helicopters. Alexander McSurely. *Aviation Week*, Vol. 52, No. 1, January 2, 1950, pp. 14–16, diagrs.

A Polish Helicopter (Glowny Instytut Lotnictwa). *The Aeroplane*, Vol. 77, No. 2011, December 23, 1949, p. 834, illus., diagr.

Convertaplane Prototype Tested (Gyrodyne Company, Helidyne). *Aviation Week*, Vol. 52, No. 3, January 16, 1950, pp. 25, 26, illus.

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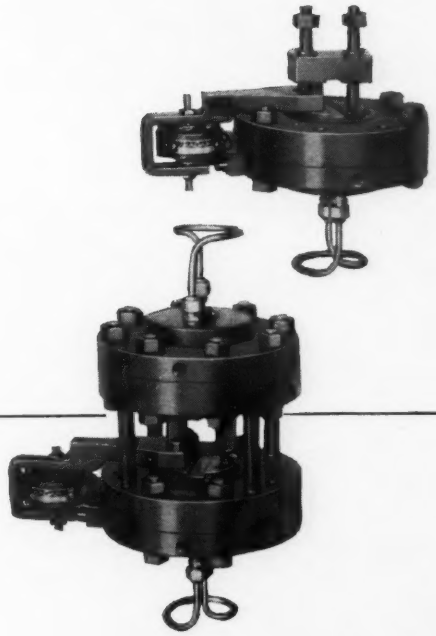

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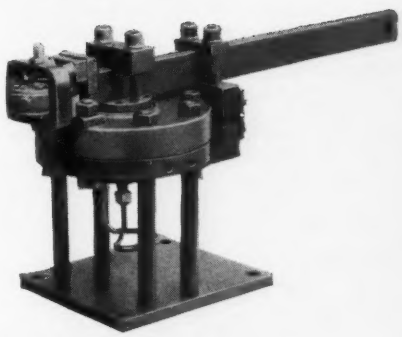

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Convertible Airplane (Convertoplane Corp. HC-60) Changes Wing Structure in Flight. James J. Haggerty, Jr. *American Aviation*, Vol. 13, No. 15, January 1, 1950, p. 14, illus.

Case for a Convertible Aircraft; Cruising Performance and Economy of Low-Aspect-Ratio Configuration Can Approach Those of Conventional Craft. Charles H. Zimmerman. *Aviation Week*, Vol. 52, No. 1, January 2, 1950, pp. 18, 21–24, illus., figs. 2 references.

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A Visit to Helicopter Utility Squadron Two. Alexander Klemin. *Aero Digest*, Vol. 60, No. 1, January, 1950, pp. 42, 43, 108–111, illus.

Sciences, General (33)

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Justification of Heaviside Methods. J. J. Smith and P. L. Alger. *Electrical Engineering*, Vol. 69, No. 2, February, 1950, p. 116. (Extended summary of a paper: A Derivation of Heaviside's Operational Calculus Based on the Generalized Functions of Schwartz.)

Essai d'une Axiomatique Aléatoire suivi de Quelques Applications. G. Dedebant. *La Plata, Argentina, Facultad de Ciencias Físicomatemáticas, Departamento de Aeronautica, Publicación No. 20*, November, 1948. 45 pp. 4 references. (In French.)

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Radiation Pressure in a Sound Wave. Robert T. Beyer. *American Journal of Physics*, Vol. 18, No. 1, January, 1950, pp. 25–29, figs. 12 references.

Structures (7)

A Note on Repeated Loading Tests on Components and Complete Structures. H. L. Cox and E. P. Coleman. *Royal Aeronautical Society, Journal*, Vol. 54, No. 469, January, 1950, pp. 1–10, illus., figs. 2 references.

A method for making repeated load tests utilizes fatigue-testing machines operating on the resonance principle, whereby the test piece may be subjected to any desired load range while the exciter need apply only a small part of the load, the magnitude of which is determined mainly by the damping of the complete system. An out-of-balance mass on a rotating disc provides fixed-load excitation. The mass is invariable and the speed range is quite narrow. Regulation is poor at true resonance speed, so the machine is run at off-resonance speed. The system is moderately good if the test piece is very stiff. When the energy absorbed by the test piece is considerable and varies widely the problems of control and regulation increase. The constant-load system works well for small power input, but for the transmission of greater power an exciter of the magnetic type is preferable because it can deliver efficiently the required force component and the frequency can be preset. Perfect regulation can be achieved by running at constant frequency with a fixed amplitude of vibration of the mass, but that method requires the use of a clutch between the driving motor and the mass, to relieve excessive starting load. At or near resonance speed, the clutch slip ceases and the mass is maintained in vibration at an amplitude determined by the throw of the driving crank. The slipping-clutch method has been applied to tests of four widely different structures—namely, aircraft wing segments, helicopter blades made of aluminum alloy tubing, elevator-hinge brackets made of magnesium alloy, and a rubber-bushed steel flexible coupling.

A Recurrence-Matrix Solution for the Dynamic Response of Elastic Aircraft. John C. Houbolt. *Institute of the Aeronautical Sciences, 18th Annual Meeting, January 23–26, 1950, Preprint No. 264* (Sherman M. Fairchild Publication). 22 pp., figs. 6 references. Members, $0.50, Nonmembers, $0.75.

A procedure for the calculation of the structural response of an airplane subjected to the dynamic loads induced by flight through gusts takes into consideration the interaction between aerodynamic loads and structural deformations. Difference equivalents for derivatives and matrix notation are used to develop a recurrence relation that permits step-by-step calculation of the response and of the loads that affect the structure. The chief feature of the recurrence approach is that the generality and physical aspects of the basic equilibrium relations of the problem are preserved without loss of ease of application. The use of difference equivalents for derivatives in the solution of dynamic problems is first illustrated by a simple damped oscillator example and the application is then made to the flexible aircraft structure. For brevity the analysis is limited to the case of wing bending and the vertical motion of the airplane, but the method can readily be extended to take into account wing torsional deformations, pitching motions, fuselage deflections, and known tail forces.

Remarks on Formulae and Numerical Methods Used in the Gust Load Calculations of Report F.28. A. I. van de Vooren. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport Nr. F.29*, May 21, 1948. 27 pp., figs. 4 references. (In English.)

Application of Simultaneous Equation Machines to Aircraft Structure and Flutter Problems. P. A. Dennis and D. G. Dill. *Journal of the Aeronautical Sciences*, Vol. 17, No. 2, February, 1950, pp. 107–113, 127, illus., figs. 1 reference.

Mathematical Principles of Flutter Analysis. J. H. Greidanus and A. I. van de Vooren. *Netherlands, Nationaal Luchtvaartlaboratorium, Amsterdam, Rapport F.43*, January 1, 1949. 84 pp., figs. (In English.)

The basic equations governing small oscillations of the fuselage-wing-aileron system of a conventional airplane are given as differential and integral equations that can be generalized to other systems. The set of basic equations in flutter analysis is not self-adjoint because of lack of symmetry of the matrix of aerodynamic coefficients which are taken from theoretical results that apply to two-dimensional incompressible flow about a thin airfoil with a control surface. The integral equations are derived for the case in which the motion of the complete system is opposed by linear springs linking the system with an immobile body. By means of the first integrals of the differential equations these springs are eliminated to obtain expressions for the deformations in the system as integrals that contain the displacements. These equations are insufficient for calculating the displacements but have to be completed by the first integrals or by relaxing

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the artificial springs and removing the characteristic roots with their vectors in the same way as when the characteristic root is unequal to zero. The analysis includes the general properties of the basic equations and their solution by approximation methods using expansions of the solution and iteration methods, the errors in the modified integral equation for higher modes, iterative methods for solving algebraic eigenvalue problems, the approximation of higher characteristic numbers and vectors from an iteration sequence for the fundamental, the accurate calculation of higher characteristic number if an approximate value is known, and perturbation methods.

On the Propagation of Plastic Deformation in Solids. Th. von Kármán. *U.S., National Defense Research Committee, Progress Report No. A-29* (O.S.R.D. Report No. 365). 7 pp., fig. 1 reference.

For the interpretation of impact and penetration problems in which the stresses exceed the elastic limit of the material and to extend present knowledge of the propagation of plastic deformation or permanent set of the material, an attempt is made to compute the stress and strain caused by such an impact beyond the elastic limit. The simple case of longitudinal impact is treated by considering a rod or wire whose end point is suddenly put in motion by an impact of constant velocity. With certain simplifying assumptions, the equation of motion for an element of the rod or wire is developed, and solutions are found for the elastic and plastic deformation and the velocity of propagation of the elastic wave. The main problem is the determination of the velocity of the plastic wave and the maximum strain as a function of the impact velocity. In the case of plastic deformation, a plastic wave front and an elastic wave front are developed, and between the two fronts the strain is variable. In that way the critical impact velocity that will cause an immediate breakdown of the material can be determined.

Planar Elasticity as a Potential Theory. Rufus Isaacs. *Tucumán, Argentina, Universidad Nacional, Facultad de Ciencias Exactas y Tecnologia, Revista, Serie A—Matematicas y Fisica Teorica*, Vol. 6, No. 2, May, 1948, pp. 263–272. 8 references. (In English.)

The use of potential functions provides a method of development for the theory of elasticity which is simpler and more concise than the conventional tensorial treatment.

Les Forces Aérodynamiques sur une Aile Vibrant Harmoniquement dans un Écoulement Supersonique. J. Dorr. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 37*, 1949. 31 pp., figs. 5 references.

Étude du Flutter en Régime Supersonique. I—Le Flutter a un Degré de Liberté; Probleme Plan. R. Weber and W. Ruppel. *France, Office National d'Études et de Recherches Aéronautiques, Publication No. 35*, 1949. 32 pp. 2 references.

A Unified Theory of Plastic Buckling of Columns and Plates. Elbridge Z. Stowell. *U.S., N.A.C.A., Report No. 898*, 1948. 11 pp., fig. 10 references. U.S. Govt. Printing Office, Washington. $0.15.

Sur la Flexion des Poutres a Section Variable et en Presence des Charges Longitudinales Continues. A. Schwartzmann-Simonot. *Techniques et Science Aeronautique*, No. 5, 1949, pp. 298–315, diagrs., figs.

Experimental Investigation of the Post-Buckling Behaviour of Flat Plates Loaded in Shear and Compression. A. Van der Neut and W. K. G. Floor. *Netherlands, Nationaal Luchtvaarthlaboratorium, Amsterdam, Report No. S.341*, 1949. 15 pp., illus., diagrs., figs. 8 references. (In English.)

Tests conducted on stiffened plates with supported edges in which a variety of longitudinal edge strains were realized by varying the stiffness of the stiffeners, indicated the adequacy of Koiter's theorem for the post-buckling behavior of stiffened plates with incomplete tension fields. The scatter of the experimental results showed the feasibility of approximating the theoretical results by simplified formulas.

Buckling of a Longitudinally Stiffened Flat Panel. H. L. Cox and J. R. Riddell. *The Aeronautical Quarterly (Royal Aeronautical Society, London)*, Vol. 1, Part 3, November, 1949, pp. 225–244, figs. 6 references.

A theoretical investigation to determine the conditions for buckling of a longitudinally stiffened flat plate in which the rotational stiffness of the stringers is negligible. The results are applied to determine the limiting characteristics of the stringers to ensure that these members remain straight, up to the stress at which the plates buckle between stringers. The analysis has been carried through in detail for panels with one, two, or three stringers and is capable of extension to four, five, or more stringers.

Compressive Strength of Flanges. Elbridge Z. Stowell. *U.S., N.A.C.A., Technical Note No. 2020*, January, 1950. 42 pp., illus., diagrs., figs. 4 references.

On Stability Problems in Thin Cylindrical Shells. K. von Sanden and F. Tölke. *U.S., Navy, The David W. Taylor Model Basin, Translation No. 33*, December, 1949. 63 pp., figs., diagrs. 20 references.

A Note on the Notch Effect of Metals. K. Minamiozi and H. Okubo. *Franklin Institute, Journal*, Vol. 249, No. 1, January, 1950, pp. 49–55, figs. 2 references.

A theoretical investigation of experimental results obtained in fatigue tests of round bars with small holes of 0.0138 to 0.0787 in. diameter. When the hole is very small, contrary to classical theory, an increase in the diameter of the hole, up to a certain limit, decreases the fatigue strength of the bar because metals in practical use are neither perfectly homogeneous nor perfectly isotropic. The endurance limit for a particular material is determined, when the diameter of the hole is not very large compared with the size of the crystals of the metal, by considering the mean stresses in a certain area around a point instead of considering the stresses at a point.

Strain Measurement by X-ray Diffraction Methods. G. B. Greenough. *The Aeronautical Quarterly (Royal Aeronautical Society, London)*, Vol. 1, Part 3, November, 1949, pp. 211–224, diagrs., figs. 16 references.

A description of the principles of strain measurement by X-ray diffraction methods. In polycrystalline metals it is possible to measure the strains in those crystals whose orientation is fixed by the direction of the incident X-ray beam and the diffraction line examined. In the absence of plastic deformation these strains may be interpreted in terms of macroscopic stresses which remain approximately constant within the volume examined. If plastic deformation has occurred, micro-stresses that vary from grain to grain probably exist in addition to macro-stresses which make it impossible to make more than a rough estimate of their relative magnitudes.

Resistance-Wire Strain Gauges. J. G. Strong. *Royal Aeronautical Society, Journal*, Vol. 54, No. 469, January, 1950, pp. 19–26, diagrs., figs.

Explanation of the fundamental principles upon which resistance-wire strain gages operate, methods of application, preparation and use of equipment, and computation of results.

The Graphical Solution of 45-Degree Strain-Rosette Data and Determination of Error in the Calculated Stresses Due to Errors in Measured Strains. Margaret E. Duke and Edward Wenk, Jr. *U.S., Navy, The David W. Taylor Model Basin, Report No. 600*, November, 1949. 18 pp., figs., diagrs. 20 references.

Aircraft Loading Figured Quickly. *Aviation Week*, Vol. 52, No. 2, January 9, 1950, p. 41, illus.

A portable electrical instrument developed by the Research and Test Laboratory of the Civil Aviation Department of India computes the center of gravity location and indicates loading adjustments for transport aircraft.

Thermodynamics (18)

A Theoretical Investigation of the Temperature Field in the Laminar Boundary Layer on a Porous Flat Plate with Fluid Injection. Shao Wen Yuan. (Polytechnic Institute of Brooklyn.) *U.S., Navy, Project Squid, Technical Report No. 4*, September 5, 1947. 21 pp., figs. 3 references.

To solve the problem of cooling rocket and intermittent-jet engines by the diffusion of fluids through porous metal combustion-chamber liners, a theoretical investigation was made of the flow of hot fluid over a porous flat plate under the condition of uniform fluid injection from the bottom of the plate. Assuming that the fluid is incompressible, that the flow is laminar, and that the injection velocity is uniformly distributed along the plate, the momentum equation and the corresponding energy equation for the boundary layer were set up and reduced to the integral relation from similar to the von Kármán integral relation of the Prandtl equation. The velocity and temperature profiles were assumed as a polynomial function of the fourth degree and also as an exponential function. Solution of the equations gave the relationship of length in the direction of flow to the boundary-

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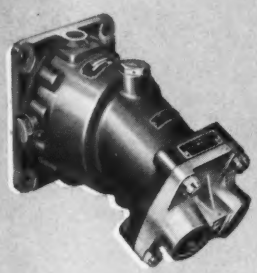

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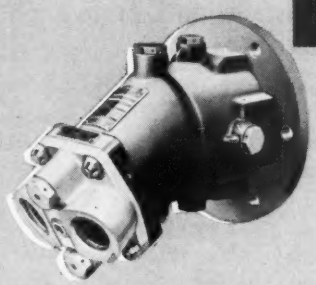

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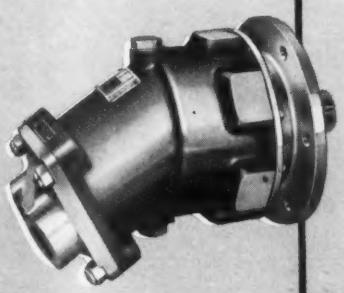

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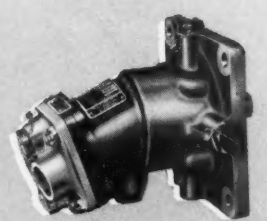

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layer thickness and to the temperature-layer thickness in the boundary layer. The velocity profiles and the temperature profiles were calculated for different Prandtl Numbers, and the solution was extended to the case where the coolant injection begins at any distance from the leading edge of the plate. The relation between the wall temperature and the rate of coolant injection was calculated for different Reynolds Numbers and Prandtl Numbers and for a partially extended plate. A linear relation exists between wall temperature and the square of the coolant injection velocity, permitting the determination of the amount of coolant required per time unit from a presumed wall temperature, provided the temperatures of the outer boundary layer and of the coolant are known. Comparison with available experimental data showed good qualitative agreement.

Water-Borne Aircraft (21)

Determination of Critical Pressures for the Inception of Cavitation in Fresh and Sea Water as Influenced by Air Content of the Water. S. F. Crump. *U.S., Navy, The David W. Taylor Model Basin, Report No. 575*, October, 1949. 37 pp., illus., figs., diagrs. 22 references.

Systematic Model Researches on the Stability Limits of the DVL Series of Float Designs. W. Sottorf. (*Jahrbuch der Deutschen Luftfahrtforschung*, 1942, pp. 451–465.) *U.S., N.A.C.A., Technical Memorandum No. 1254*, December, 1949. 49 pp., illus., diagrs., figs. 7 references.

Landing Procedure in Model Ditching Tests of Bf 109. W. Sottorf. (*Deutsche Versuchsanstalt für Luftfahrt, Institut für Seeflugwesen.*) *U.S., N.A.C.A., Technical Memorandum No. 1247*, December, 1949. 38 pp., illus., diagrs., figs.

Wind Tunnels (17)

Vliv Pružnosti Modelů a Jejich Závěsů na Výsledky Měření v Aerodynamických Tunelech (The Influence of Elasticity of Models and their Suspension Systems on Results of Measurements in Windtunnels). V. Smolar. *Prague, Letecký Výzkumný Ústav (Aeronautical Research Institute), Zpráva Č. 1*, 1947. 205 pp., figs. (Extract in English, pp. 153–205.)

A detailed analysis is made of the influence of the elasticity of the structure of aircraft models and of the elasticity of suspension mechanisms in wind tunnels, in the measurement of aerodynamic forces. Mathematical formulas are developed for the calculation of corrections for those elastic qualities, for errors in weighing, and for variations in the position of the model caused by the elasticity of the suspension wires and the balance beams. The method was applied to measurements made in the six-component balance in the 3-meter wind tunnel at Prague and showed that it is possible to correct such variations and to determine what elastic influences can be neglected.

Aerodynamic Characteristics of Damping Screens. G. B. Schubauer, W. G. Spangenberg, and P. S. Klebanoff. *U.S., N.A.C.A., Technical Note No. 2001*, January, 1950. 39 pp., diagrs., figs. 9 references.

Hypersonic Wind Tunnel for Continuous Operation. *Automotive Industries*, Vol. 102, No. 2, January 15, 1950, pp. 50, 112, diagr.

N.A.C.A. Lewis Laboratory Supersonic Wind Tunnel. *Shell Aviation News*, No. 137, November, 1949, p. 23, illus.

Symposium on Jet Installation Design Problems

(*Continued from page 47*)

radical airplane. By their concept, a jet is a radical, because you gentlemen and I are a little bit more familiar with it and they aren't. However, you tell them that it doesn't have an emergency fuel system, and immediately they're going to put in for transfer.

I might also mention this idea of the fuel counter. I'm afraid there that I'm going to have to disagree with the gentlemen. I have flown a few of the Air Force planes and favor the idea of having an accurate fuel gage within the small wing tanks. One airplane, which some of you gentlemen are familiar with and on which they went to such lengths to find a space for fuel, only holds 6 gal., and I can't see a liquidometer fuel gage that would give you a true indication in this case. I don't try to defend the errors of the fuel counter—that's true—but I think that where we take young pilots that are used to, say, a power of 2,800 or 2,600, if they're used to running at 60 to 70 gal. per hour in cruise (maybe 90) and you put them in an airplane that is going to use 300 to 400 gal. per hour, I don't think you're going to rely on their judgment. I think that you're going to have some type of fuel counter. It is a little bit easier in the Navy aircraft where you have all your fuel carried internally—that is, within the fuselage. However, I don't think that as long as you have wing tanks you'll be able to get around that, at least not satisfactorily, for some time. One speaker brought up the fact that, if we had an accurate liquidometer gage, we could do away with the fuel counter. This is true. I came back and landed one time, and I had 2 gal. registered on my liquidometer gage. We drained it out and we had 2 gal. That's pretty doggoned accurate. I might point out that that was through no fault of my own. I couldn't possibly defend it much more.

I have enjoyed this little tête-à-tête between the engine manufacturers and the airplane manufacturers. One of them says: "Well, it's your fault we need this"; the other says: "No, it's your fault we need this." I won't defend it. I'll admit it. I won't blame it on Admiral so-and-so, or Commander so-and-so, or General so-and-so of the Air Force. I'll just put it right up to me, because I go up there at 40,000 ft. and work on fighter intercept and I come back down and say that things didn't work out too well. You gentlemen, in your initial mock-up stage, have decided just what you can put in that airplane. I know that, and there's nothing I can do about it. But in spite of that, I come back down and say I couldn't see too well. Take a typical example. From 30,000 ft. on up, about the absolute maximum of positive identification is $5^1/_2$ miles. At 600 m.p.h. that gives me 32 sec. to make an intercept. I can't do it. So I come down and say I must have something in there. We walk over to you and say: "We're sorry, but this has got to go in," and there goes 40 lbs. of radar gear. So, I'll take the blame for that as much as anybody. We can't get around that.

Mr. Robinson: I'm glad to know that the aircraft industry can appear and discuss their problems so honestly and openly. Ray Small had the final answer. It's the end result that counts, and that's what we're all working toward.

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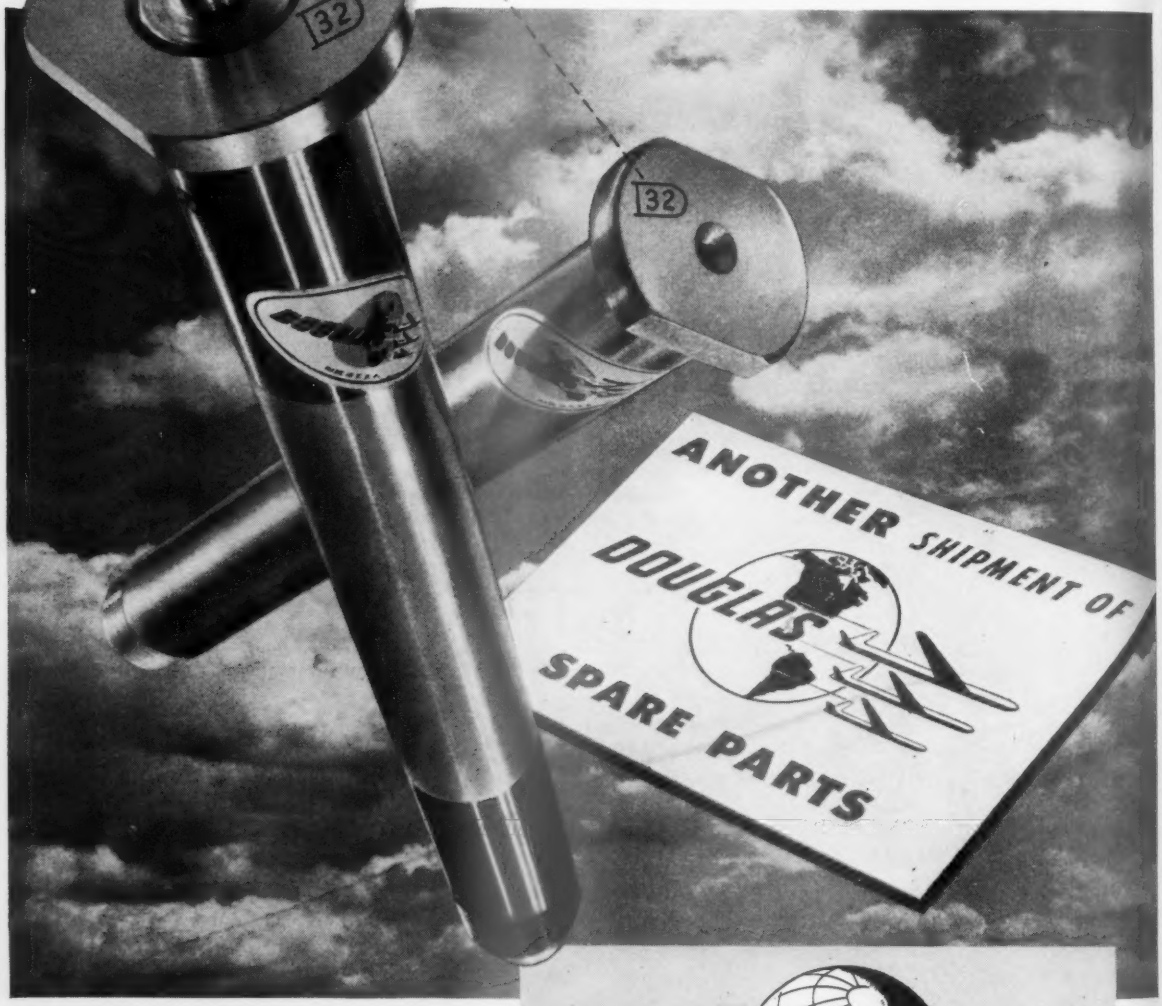

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

Aeronautical Reviews

Books

Engineering Supersonic Aerodynamics

By E. Arthur Bonney. New York, McGraw-Hill Book Company, Inc., 1950. 264 pp., illus. $4.00.

As Mr. Bonney stresses in his preface: "The purpose of this book is to present the basic information on the subject of supersonic aerodynamics which should be included in the background of knowledge of every aeronautical engineer in this field. The particular goal has been to present the practical applied information which would be desired by the engineer in understanding the physical principles of the subject and the necessary essentials for designing and predicting the performance of supersonic aircraft. The material particularly avoids concentration on the mathematical details of any specialized branch of the field and is not intended as a reference text for specialists in the field. It is written on a level for senior college students who have had only an introductory course in conventional subsonic aerodynamics and only the simplest fundamentals of differential equations."

The book fulfills this requirement in an admirable manner. Any engineer just entering the field of supersonic aviation would profit by the excellent physical interpretations and explanations of supersonic flow phenomena. The book would not be suitable as a text in a formal course on supersonic aerodynamics since Mr. Bonney has deliberately avoided all the mathematical derivations that would disturb the continuity of the physical picture he is presenting of supersonic flow.

Chapter One deals with the physical aspects of compression and expansion waves, and Chapter Two follows with all the simpler derivations for the isentropic flow and normal shock wave equations for one-dimensional flow. Chapter Three presents the final results and equations for the exact and approximate solutions of isentropic flow and oblique shock waves, and these results are applied to determine the characteristics of two-dimensional airfoils in Chapter Four. This chapter concludes with a physical discussion of the effects of finite aspect ratio on three-dimensional wing characteristics and the effect of sweepback. The final equations and graphical results of available studies on finite aspect ratio wings of various plan forms (including pressure distribution, lift, drag, and downwash) are presented in a concise manner. Chapter Five presents the graphical results of the conical shock wave solution by Taylor and Maccoll and the linearized theory solution for bodies of revolution by von Kármán, Tsien, and Ferrari. Chapter Six is a descriptive introduction to the supersonic wind tunnel construction and experimental procedures. Chapter Seven briefly discusses the physical aspects of wing-body-tail interference, propulsion, and performance.

A few omissions and errors noted were: (1) An insufficient discussion of the entropy and enthalpy changes across a shock wave. A recent engineering graduate would be especially prepared better to comprehend the physical picture of a shock wave if his attention were focused on the increase of entropy rather than the decrease of total pressure. (2) On page 81 the density variation is erroneously limited to $1/_6$ in the expansive case. Flow expansion is isentropic without shock so the density can approach zero. (3) On page 182 it should be pointed out that experimental data agree with the Busemann theory and the Tsien and Ferrari results contain a theoretical error that produces an excessive decrease in lift with Mach Number. (4) On page 191 the derivation should be based on $F = m\Delta v$ and not $F = ma$ since $V\alpha = \Delta V \neq a$. (5) On page 231 no clarification is made of the fact that the total wing area, including the portion covered by the body, may be used to provide a satisfactory approximation of the combined lift of a wing-body combination.

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Mechanical Engineering
University of California

For information on I.A.S. Library Service Facilities, see page 59

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Aircraft Structures

By David J. Peery. New York, McGraw-Hill Book Co., Inc., 1950. 566 pp., diagrs. $6.50.

Teachers and students in the field of aircraft structures will find this new book, "Aircraft Structures" by David J. Peery, a welcome addition to the technical literature on this subject. The author, who is Professor and Head of the Department of Aeronautical Engineering at The Pennsylvania State College, has done a remarkably good job in presenting the basic material for the stress analysis of semimonocoque as well as truss types of structure in such a concise and simple manner. The wealth of the material covered in this book is, however, not readily seen from a glance at the chapter headings.

The first two chapters deal with the equilibrium of forces in two- and three-dimensional structures, and many examples are given in terms of actual airplane structure components. The third chapter treats the inertia forces and load factors and provides a brief discussion of converting a dynamic problem into a static equilibrium problem. The method of evaluating the moments of inertia in the general case, and for semimonocoque structures in particular, and the determination of principal moments of inertia by means of Mohr's circle is presented in Chapter 4.

The next three chapters treat the shear and bending moment diagrams, and the shear and bending stresses in symmetrical and unsymmetrical beams under bending and torsion. This includes the analysis of stiffened box beams with taper and beams with variable flange areas. The analysis of typical members of semimonocoque structures is treated in Chapter 8. Such analyses as distribution of concentrated loads to thin webs, loads on fuselage bulkheads, analysis of wing ribs, shear flow in tapered webs, and cutouts in semimonocoque structures are the material discussed in this chapter.

The determination of the spanwise air-load distribution, a topic which is not usually covered in a structures book, is included in the next chapter. Then comes a discussion on the basic flight loading conditions and the determination of load factors in the next chapter. The arrangement of these topics in the middle of the book

is somewhat a deviation from the usual presentation of an airplane structure book. The reason for this is pointed out by the author—these topics require a knowledge of aerodynamics and not until this time will the student have the necessary prerequisite aerodynamics in concurrent courses.

Chapter 11 presents a good discussion on the mechanical properties of aircraft materials. Nondimensional stress-strain diagrams following the Ramberg and Osgood method are included. The method of analysis of joints and fittings is given in Chapter 12.

Chapter 13 presents the method of design of members in tension, bending, or torsion when the structure parts are loaded beyond the elastic limit. The buckling of columns, plates, and shells is treated in Chapter 14. The behavior of plates after buckling, and of columns subjected to local crippling failure also is discussed. Discussion of the tension field beam is the subject of the next chapter.

Chapter 16 gives the methods in the determination of deflections in either the truss type of structures or the semimonocoque type of structures by means of the method of virtual work and the Castigliano's Theorem. Statically indeterminate structures are treated in Chapter 17. In this chapter the stress analysis of fuselage rings, multicell wing structures, and shear lag calculations is given.

In the last chapter a group of special methods of analysis is presented. These so-called special methods are the moment area method and the conjugate beam method for the determination of the deflection of beams, truss deflection by elastic loads, beam columns, and the moment distribution method for both continuous beams and continuous beam columns.

As the author has pointed out, this book is mainly written as a textbook for an undergraduate course, and indeed it has ample material for a year's course. The reviewer particularly is pleased to see that such topics as analysis of monocoque structures with cutouts, bending stresses induced due to torsion, shear lag analysis, and explanation of the buckling of cylindrical shells by means of the nonlinear theory, are briefly included in this book. These topics, as far as the reviewer is aware, are not taken up in any other structure book of this level. Professor Peery is to be congratulated for having brought these difficult topics into the undergraduate level in such a simple way of presentation.

DR. C. T. WANG
Associate Professor of
Aeronautical Engineering
New York University

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Numerical Methods of Analysis in Engineering (Successive Corrections)

Arranged and edited by L. E. Grinter. New York, The Macmillan Co., 1949. 207 pp., figs. $5.80.

The practicing engineer often solves a complex problem in an intuitive manner, using only the most elementary principles of physics. His intuition is based on many years of practical experience with problems of similar complexity. The research man in a laboratory or academic institution is more likely to simplify the practical problem by stripping it of all its incidental features until a bare skeleton is left which is amenable to rigorous mathematical treatment. The first approach is unsatisfactory because of the inaccuracy of the analysis, and the second because of the idealization of the problem. The procedures discussed in "Numerical Methods of Analysis in Engineering," a small volume dedicated to Professor Hardy Cross, are midway between these two extremes and for this reason are attractive to engineers who wish to improve their methods of design and analysis.

Although it is possible to point out many earlier applications of numerical methods to the solution of problems in engineering, it is an undeniable fact

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that the idea of a numerical analysis of beams and rigid frames was generally accepted by structural engineers and developed to an easily learned routine only after Professor Hardy Cross published his now famous paper "Analysis of Continuous Frames by Distributing Fixed-End Moments" in the *Proceedings of the American Society of Civil Engineers* in 1930. It is fitting, therefore, that this volume, which resulted from a symposium on numerical methods held at the Illinois Institute of Technology, begins with a reprint of Cross' paper. This publication is a clear and concise presentation of the principles of moment distribution and contains a fully worked out numerical example, all on 12 pages.

The same basic physical and mathematical principles that underlie the Hardy Cross moment distribution method can serve as a foundation for a much more general procedure of analysis useful not only in structures but also in the general theory of elasticity, plasticity, aero- and hydrodynamics, thermodynamics, and electrical network theory. This so-called relaxation procedure was proposed and worked out in detail by Professor R. V. Southwell and his collaborators in a long series of papers published since 1935. It lends added distinction to the book that Professor Southwell is the author of one of its chapters. From the standpoint of the user, one of the main differences between the moment distribution and the relaxation procedures is that the former always converges rapidly provided the effect of axial loads is neglected, as is usually the case; on the other hand, in the relaxation method a great deal of ingenuity must be exerted in order to arrive at a practical answer with a reasonable effort. Many authors on relaxation have centered their attention on devising sequences of operations that improve the rate of convergence of the process.

As the articles collected in this volume were originally prepared for a symposium by fourteen different authors, they differ considerably in subject matter, style, and method. The editor of the volume, Professor L. E. Grinter of the Illinois Institute of Technology, who was responsible for some of the early modifications of the moment distribution technique, is the author of the second chapter entitled "Statistical State of Stress Studied by Grid Analysis." Always attracted by physical models, Professor Grinter now proposes the use of an analogous grid in calculating the stresses in a plate loaded in its own plane. The article contains numerical examples and is followed by an appendix in which Andrew J. Pyka of the Standard Oil Company of Indiana calculates the stresses in a notched beam.

The two papers on heat flow deal mainly with details of the arrangement of numerical calculations. The author of one of them, "Two Problems in Building Heating Solved Numerically," is G. M. Dusinberre, Professor of Mechanical Engineering (at the University of Delaware according to the footnote to the paper, and at The Pennsylvania State College according to the introduction). The appendix, "Temperature Distribution Through Ground," is the work of J. D. Bottorf and Y. S. Touloukian, both of Purdue University. "Numerical Solutions for Thermal Systems" by L. M. K. Boelter and Myron Tribus, both of the University of California, Los Angeles, also contains an analysis of the accuracy of the procedure and the rapidity of its convergence.

The other extreme is represented by the article, "Successive Corrections—A Pattern of Thought," in which Professor Frank Baron of the Northwestern Technological Institute presents general considerations, and the chapter entitled "A Survey of the Approximate Solution of Two-Dimensional Physical Problems by Variational Methods and Finite Difference Procedures" written by Professor Thomas J. Higgins of the University of Wisconsin. The latter is definitely more mathematical than the other parts of the book and Professor Higgins fails to show how his summary of the variational methods can be of any possible use to the numerical calculator, or even to the research man developing numerical methods. The bibliography following this chapter contains 140 titles.

Professor N. M. Newmark's paper, "Numerical Methods of Analysis of Bars, Plates, and Elastic Bodies," is a survey and classification of the numerical procedures available today to the engineer. In addition, it presents the fundamental concepts of the continuity restoration or compatibility method developed by the author at the University of Illinois, in each step of which static equilibrium is maintained rigorously while the compatibility condition of deformations is satisfied approximately only by the sum total of the steps undertaken. This is a counterpart of the moment distribution and relaxation procedures in which the compatibility condition is satisfied in each step and static equilibrium is approximated only after a large number of operations.

A clear and concise presentation (17 pages) of the relaxation method in its latest form is given by an early collaborator of Southwell, F. S. Shaw of the Division of Aeronautics, Council for Scientific and Industrial Research, Australia. The author shows how partial differential equations are replaced by their finite difference equivalents, the many resulting simultaneous linear algebraic equations solved by systematic relaxations, and how the convergence of the process can be accelerated by the use of suitable operators. In the next chapter R. V. Southwell proposes an ingenious device by which the solution of the biharmonic equation can be reduced to the more rapidly converging procedure for solving Laplace's equation. He also expresses his preference for finer nets rather than improved finite difference equivalents for differential equations when greater accuracy is desired. As the best means for accelerating the convergence of the relaxation method consists in obtaining a rather accurate first approximation to the solution, Professor M. M. Frocht of the Illinois Institute of Technology, who is an authority on photoelasticity, proposes a procedure, the linear rosette method, for determining initial values. He shows how this method can be applied to problems in photoelasticity.

In conclusion it can be said that persons who have never heard of numerical methods might find the book a little hard to read, but those having some familiarity with the methods should be able to follow the chapters easily and profit from their contents.

Dr. N. J. Hoff
Professor of Aeronautical Engineering
Polytechnic Institute of Brooklyn

Rocket Propulsion Elements

By George P. Sutton. New York, John Wiley & Sons, Inc., 1949. 294 pp. $4.50.

After a long series of the popular science-fiction type of book on rockets which at this late date must have served their original purpose of quickening interest and support for the ultimate in propulsion methods, it is a pleasure to welcome an up-to-date first specialized textbook on the subject.

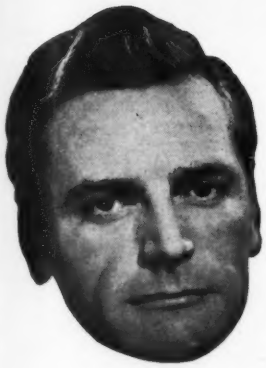
Naturally, "up-to-date" in the rocket propulsion field, as in others of military interest, for security reasons means only as far as the available unclassified or "declassified" material will permit. In spite of this universal handicap, Mr. Sutton has done an excellent job of putting into one book the fundamental elements of the subject with enough practical as well as theoretical information to interest both the worker in the field and the new student.

The text includes 10 chapters well illustrated with about 37 detailed sketches or schematics of components, and 34 photographs. There are 57 graphs and 29 tables covering various properties of propellants and materials, and over 100 references to the existing literature in the field. Representative problems with solutions, are included, together with several more appended at the end of the chapters.

Perhaps the best method of conveying an adequate idea of the contents is to list the topics of the 10 chapters.

Chapter 1 on Classifications and Definitions distinguishes between turbojets, ram-jets, pulse-jets, and rockets and acquaints the reader with the nomenclature in more or less general use.

Chapter 2 on Rocket History traces the background briefly from ancient



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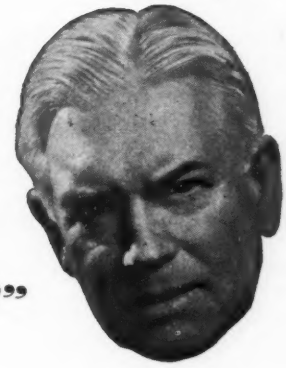

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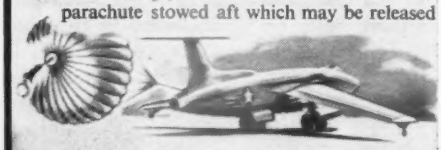

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Chapter 3 on Nozzle Theory and Thermodynamic Relations summarizes the fundamentals of analysis and design which should offer no trouble to the undergraduate student who has a grasp of elementary thermodynamics.

Chapter 4 on Rocket Propellant Performance Calculations shows how the theoretical performance of several propellant (fuel plus oxidizer) combinations may be estimated.

Chapter 5 on Liquid Rocket Propellants describes their properties, both desirable and undesirable.

Chapter 6 on the Liquid Rocket Motor digs into the more complex problems such as cooling the walls to withstand the high heat transfer from the 4,000° to 6,000°F. combustion gases, and the design of the propellant injector.

Chapter 7 on Liquid Propellant Feed Systems describes the gas pressurization and turbopump methods, together with their principal accessories.

Chapter 8 on Flight Performance reviews the basic relations of motion in air and in vacuo.

Chapter 9 on Rocket Testing gives the reader an idea of the more exciting phase of the work with due warning of the safety precautions to be taken to avoid the ordinary hazards encountered in handling high-energy propellants and high pressures.

Chapter 10 on Solid Propellant Rockets concludes the book with a survey of the special considerations involved in the use of smokeless powder and other solid compositions.

Backed by several years of experience with rockets and recent developments in his work at North American Aviation, the author has made a worth-while contribution to the literature of rocket engineering, which is recommended for reading by any serious student of the subject.

ALFRED AFRICANO
Staff Engineer
Rocket Department
Propeller Division
Curtiss-Wright Corporation

Aircraft Maintenance and Service

By Col. R. H. Drake. New York, The Macmillan Company, 1949. 352 pp., illus., tables. $6.00.

This book, the sixth in Drake's Aircraft Mechanics Series, is a valuable addition to the libraries of those concerned with the problems of aircraft maintenance. Though its greatest value is to individuals in the light-aircraft field, much of the basic material is also of value to maintenance personnel employed in military and air-line operations.

The book includes chapters on Component Parts, General Maintenance, Inspection, Materials, Methods

of Repair, Shop Practices, Technical Drawings, Safety Practices, Assembly, and an excellent Glossary. The illustrations and photographs are adequate, modern, and well chosen, and some valuable tables are included.

Of special note is the section on wood and wooden construction, subjects which are treated in much greater detail than is found in texts of similar nature. The sheet-metal sections contain much worth-while information, including a comprehensive explanation of bend allowances.

Some criticism may be leveled at the method used in Chapters XV and XVI to teach Fabric-Covered Construction and Plywood Construction. It is questionable whether the procedure followed—the basing of all instruction upon specific measurements of hypothetical wing and fuselage components—is of general application. For example, no instruction is included as to the laying out of rib contours of sizes or shapes differing from the one detailed in Chapter XV.

It is this reviewer's belief that, with the exception of the chapter concerning Inspection, this book suffers somewhat from too much narrative or lecture type of presentation. A great deal of practical information, often lacking in other books which depend too much on abstracts from trade publications, is to be found in the text but the hurried reader has to dig through several sentences in some cases to find these items. A more frequent use of the tabular method of presenting related material would have improved the readability.

CHARLES C. GREENE
Aeronautics Teacher
Board of Education
New York City

The Aircraft Year Book for 1949

Official Publication of The Aircraft Industries Association of America, Inc., Washington 4, D.C., Lincoln Press, Inc., 1950. 464 pp., illus., diagrs. $6.00.

This year's *Aircraft Year Book* includes some entirely new features. The most noticeable is a 79-page review of planes in production, containing photographs, three-views, uniform specifications, performance figures, and remarks about each airplane. This section contains a considerable amount of information conveniently arranged. Reviews of the industry, military and civil government aviation activities, air lines, light planes, and new developments in airborne equipment comprise about half the book. These sections will be familiar to users of this annual, but a number of other sections are new. There is a list of 90 aviation books published in 1949, compiled by Arthur G. Renstrom of the Library of Congress. There is a 1949 chronology, day by day, and a chronology of U.S. aviation, compiled by Ernest L. Jones. Over 1,000 names are included in the section of biographical briefs. The list of engines in production includes, besides basic data on each engine, the names of manufacturers of its auxiliary equipment. There is a list of planes in use, civil and military, with brief data on each plane, and notes on more than 20 advanced designs or research types. The list of official world air records occupies 24 pages and is preceded by a résumé of procedures in establishing records, with a schedule of the fees. Statistics of the manufacturing and air-line industries are included, and the directory section includes an up-to-date list of over 65 American publications, with their addresses and the names of their editors. Companies, Government agencies, and organizations also are listed in the directory section. There is a section describing 21 planes that made U.S. aviation history, giving their locations in museums. The editors of this annual volume are Fred Hamlin, Arthur Clawson, William G. Key, and Eleanor Thayer. They have produced a volume of considerable usefulness and set an example for future annual volumes which can be followed with profit. Special mention should be made of the detailed index to the book, compiled by Miss Agnes Gautreaux of the Civil Aeronautics Administration.

MAURICE H. SMITH
Librarian, I.A.S.

Book Notes

AERODYNAMICS

The Measurement of Air Flow. E. Ower. 3rd Edition Revised. London, Chapman & Hall, Ltd., 1949. 293 pp., illus., diagrs. 30*s*.

This textbook was last revised in 1933. The present edition has been revised throughout, with numerous additions, including a new chapter on flow in pipes, developing the subject as a particular example of boundary-layer flow. Flow in curved pipes and the reduction of losses in bends by the use of guide vanes are included in this chapter. The chapter on plate orifices, venturi tubes, and shaped nozzles has been largely rewritten, taking into account German work published from 1932 to 1939. Experimental verification of assumptions made in earlier editions on the behavior of a vane anemometer in a fluctuating air current has been included, and descriptions of various instruments and methods of measurement, such as the rotameter and the ordinary gas meter, have been included. The book is designed for students and for engineers engaged in work involving both speeds and pressures of moving air, such as ventilation and fan engineering. Bibliographies are included at the ends of chapters. The author was for many years senior physicist with the National Physical Laboratory.

Hydro- und Aerodynamik. 3 Teil. Technische Anwendungen (Hydro- and Aerodynamics. Part 3. Technical Applications). Edited by Ludwig Schiller. (Handbuch der Experimentalphysik. W. Wien and F. Harms, v. 4, part 3.) (Leipzig, 1930). Ann Arbor, Mich., J. W. Edwards, 1948. 557 pp.. illus., diagrs. $14.50.

The first section, by Fritz Horn, consists of 114 pages on towing basin research, including research on ship models, propellers, rudders alone and in combination, towing basins, and measuring equipment and methods. The next section, of 20 pages, by R. Emden, deals with free balloons. Airship-testing methods are next discussed, by Wolfgang Klemperer, in a section of 76 pages. Flying technique and flight research are discussed in the next 56 pages, by Ludwig Hopf, including gliding and powered flight, flight testing, measurement of stresses, longitudinal and lateral stability, and flutter. Centrifugal pumps and turbines are covered in the next 56 pages, by W. Spannhake, and aircraft propellers in the following 90 pages, by O. Flachsbart. W. Gaede discusses compressors and low- and high-vacuum pumps in the next 53 pages, and the final section of 73 pages, by O. von Eberhard, deals with ballistics. Extensive footnote references are given throughout, and author and subject indexes are included.

AERONAUTICS, GENERAL

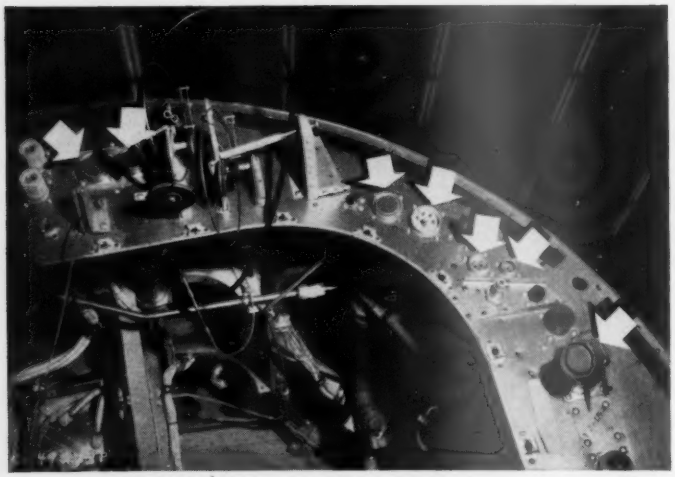
Second International Aeronautical Conference, New York, May 24–27, 1949, convened by the Institute of the Aeronautical Sciences and The Royal Aeronautical Society. New York 21, Institute of the Aeronautical Sciences, Inc., 1950. 739 pp., illus., diagrs. $17.50 ($15.00 to members).

Contents: Optimum Fields of Application for Air-Consuming Aircraft Power Plants, W. G. Lundquist and G. S. Kelly; The Propeller Gas Turbine in Service, F. M. Owner; Recent Design Refinements in Turbojet Engines, N. Burgess and J. C. Buechel; Turbine-Engined Transport Aircraft, George R. Edwards; Research on Helicopters at the R.A.E., with Special Reference to the Stability of the Multirotor Helicopters, H. B. Squire; Operation Whirlwind—Past, Present, Future, C. M. Belinn; Aircraft Materials from the Designer's Point of View, A. E. Russell; Materials from the Aircraft Manufacturer's Point of View, P. Litherland Teed; Materials in the Aircraft Industry, Clyde Williams; Aeroelastic Problems at Supersonic Speed, A. H. Flax; The Life of Aircraft Structures, H. A. Wills; American Structural Design Trends, G. G. Green; The Relative Merits of Auxiliary Power Systems—the Case for Hydraulic, H. G. Conway; The Relative Merits of Auxiliary Power Systems—the Electrical Aspect, R. H. Woodall; The Relative Merits of Auxiliary Power Systems—the Case for Pneumatics, H. R. Haerle; Aerodynamically Boosted Surface Controls and Their Application to the DC-6 Transport, Orville R. Dunn; Comparison Between Theory and Experiment for Wings at Supersonic Speeds, Walter G. Vincenti; Some Considerations of the Flutter Problems of High-Speed Aircraft, E. G. Broadbent. Flight Research at Transonic and Supersonic Speeds with Free-Falling and Rocket-Propelled Models, F. L. Thompson; The Relative Efficiencies of Large Landplanes and Flying Boats, D. Keith-Lucas; Aerodynamic Efficiencies of Large Landplanes, George S. Schairer; Operating Factors Affecting the Design of Future Civil Transport Aircraft, Christopher Dykes; Utilization Factors and Maintenance of Civil Aircraft, Warren E. Alberts.

Association Technique Maritime et Aeronautique, Bulletin No. 48, Session de 1949. Paris, 1949. 906 pp., diagrs.

Partial Contents: La Conférence Internationale pour la Sauvegarde de la Vie Humaine en Mer; la Nouvelle Convention de Londres (10 juin 1948), J. Pinczon and A. Sudige; Sur les Conditions de Production des Déchirures semi-fragiles, H. de Leiris; Application des Méthodes Harmoniques à la Mécanique du Vol, J.-C. Gille; L'Atterrissage par mauvaise visibilité, E.-R. François; Considérations sur un Système de Pilotage, P. de Valroger; Stabilité et stabilisation des aérodynes, L. Frager; Étude de l'Équivalence des essais en court-circuit en courant alternatif à basse tension et basse frequence par rapport aux essais en

LOCKHEED CONSTELLATIONS ARE PROTECTED by CANNON FIREWALL PLUGS



Arrows point to several Cannon Type K Firewall Connectors on portion of Constellation Engine Firewall. Included are Flame Barrier and Fireproof Types.

Just as Cannon Electric pioneered and developed the standard multiple-circuit electric connector for the aircraft industry back in the 30s, Cannon also was first to meet the requirements of the aircraft manufacturers and airlines under CAA regulations for engine firewall or bulkhead fireproofing toward the greater safety in air travel.

Cannon Firewall Connectors, whether in the "K", "RK" or "FW" (AN) series are made in two fundamental types: Flame Barrier and Fireproof. Both types have steel shells and are used with steel conduit. The main difference is the material of the insulators, and type of contacts.

Complete information on Cannon Firewall Connectors is given in ANF Bulletin and the Firewall Section of the K3 Bulletin. Both will be sent gratis upon request.

Address Cannon Electric Development Company, Division of Cannon Manufacturing Corporation, 3209 Humboldt St., Los Angeles 31, California. In Canada: Cannon Electric Company, Ltd., Toronto. World Export: Frazar & Hansen, San Francisco, Los Angeles, New York.

SINCE 1915

CANNON ELECTRIC

REG. U.S. PAT. OFF.

Court-Circuit en Courant Continu, R. Chambrillon; Considérations Théoriques et Pratiques sur le Matériel Marin de Sondage, P. Rivére; Note sur la Stabilité du Régime de Route des Navires, J. Dieudonné; Roulis en Marche, R. Brard; Remarques sur la Tenue à la Mer, J. Dieudonné; L'État actuel des Calculs de Résistance de Vagues, W.-C.-S. Wigley; Houle, Roulis, Tangage, Stabilisation, A. Pommellet; Perfectionnements des Compas Magnétiques des Systèmes Compensateurs des Appareils de Mesure de Champ, F. Bellon and J. Lenoir; Contribution à l'étude Expérimentale des Écoulements Supersoniques, Application aux Éjecteurs à Vapeur, Ch. Cabanes and J. Chalom; La Visualisation Chronophotographique des Écoulements d'Air, J.-M. Bourot; Problèmes relatifs aux Turbomachines Axiales, R. Legendre; L'Alliance de la Turbine a Gaz et de la Machine à vapeur, R. Waeselynck; Le Rendement des Générateurs de Gaz à pistons libres; Considérations Théoriques et Résultats Expérimentaux; Perspectives d'Avenir, L. Peillon; Étude d'un Courant Théorique et Médian dans un Rotor à Palettes Radiales, M. Roy; Procédé Graphique de Détermination des Fréquences Propres de Torsion des Lignes d'Arbres, A. Ulrich and A. Giraudeau; Calcul de la Fréquence propre des Vibrations par Flexion des Poutres Creuses, J. Barthélemy; Détermination des Fréquences Propres de Vibrations de Torsion des Lignes d'Arbres au Moyen d'une Analogie Electrique, M. Ballet; and Sur la Possibilité de Calculer au Moyen du Principe de Lagrange la Pression Critique de Flambement des Enveloppes de Révolution, J. Barthélemy.

Non-Linear Problems in Mechanics of Continua. (Proceedings of Symposia in Applied Mathematics, vol. 1). New York, American Mathematical Society, 1949. 219 pp. $5.00.

Contents: Non-Linear Problems in the Theory of Fluid Motion with Free Boundaries, Alexander Weinstein; Operator Methods in the Theory of Compressible Fluids, Stefan Bergman; An Existence Theorem in Two-Dimensional Gas Dynamics, Lipman Bers; Recent Developments in Free Boundary Theory, Garrett Birkhoff; Theory of the Propagation of Shock Waves from Cylindrical Charges of Explosive, Stuart R. Brinkley, Jr., and John G. Kirkwood; The Method of Characteristics in the Three-Dimensional Stationary Supersonic Flow of a Compressible Gas, N. Coburn and C. L. Dolph; The Numerical Solution of the Turbulence Problem, Howard W. Emmons; On the Stability of Transonic Flows, Y. H. Kuo; Stability of the Laminar Boundary Layer in a Compressible Fluid, Lester Lees; Remarks on the Spectrum of Turbulence, C. C. Lin; Two-Dimensional Compressible Flows, I. Opatowski; Polygonal Approximation Method in the Hodograph Plane, H. Poritsky; The Boundary Layer of Yawed Cylinders, W. R Sears; On Shock-Wave Phenomena: Interaction of Shock Waves in Gases, H. Polachek and R. J. Seeger; The Breaking of Waves in Shallow Water, J. J. Stoker; On Hamilton's Principle for Perfect Compressible Fluids, A. H. Taub; The Foundations of the Theory of Elasticity, F. D. Murnaghan; On Dynamic Structural Stability, G. F. Carrier; Stress-Strain Relations for Strain Hardening Materials. Discussion and Proposed Experiments, D. C. Drucker; The Edge Effect in Bending and Buckling with Large Deflections, K. O. Friedrichs; Numerical Methods in the Solution of Problems of Non-Linear Elasticity Wilfred Kaplan; Large Deflection Theory of Rectangular Plates, Samuel Levy; Discontinuous Solutions in the Theory of Plasticity, William Prager; and On Finite Deflections of Circular Plates, Eric Reissner.

AIR TRANSPORTATION

Domestic Mail Rate Decisions. Frederic P. Kimball. Tarrytown, N.Y., The Author, August 20, 1949. 258 pp. Mimeographed. $175 (discount to universities and eleemosynary companies).

This is a summary and analysis of opinions of the Civil Aeronautics Board granting permanent

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Time was short. America's growing air power needed more horsepower . . . fast! In a matter of weeks, the famous Liberty V-12 engine was designed, tested and put in mass production. A great engineering achievement for its day! The Liberty's crankcase, oil pan, pistons and rocker-arm box were Alcoa Aluminum—giving it the lightest "lbs.-per-hp" rating among World War I aircraft engines.

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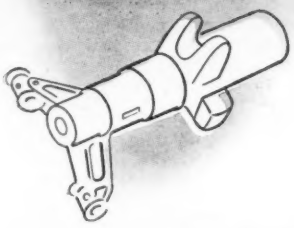

Today's "hot" planes demand structural strength that challenges the designer's ingenuity. Alcoa 75S-T6 alloy has physical properties to meet these new conditions. And now Alcoa is producing 75S forgings in a wide range of sizes and shapes to fit aluminum's strongest alloy to your new designs.

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ALCOA ALUMINUM MAGNESIUM

mail rates currently in effect for domestic air carriers. It is written primarily from the economic point of view, and the material is arranged by subject matter in 14 sections: Decisions Summarized and Rates Set; Comparable Carriers; Scheduled Services Required; Flight Equipment; Non-Mail Revenues; General Operating Expenses; Flying Operations Expense; Direct Maintenance Expense; Depreciation—Flight Equipment; Ground and Indirect Expense; Miscellaneous Costs and Credits; Recognized Investments; Detailed Investment Adjustments; Determination of Mail Rates. The air lines surveyed are Braniff, Capital, Chicago and Southern, Continental, Delta, Empire, Florida, Inland, Mid-Continent, Monarch, Northeast, Pioneer, Southwest, West Coast, and Western. Certain statistics implied in opinions, but not specifically presented, have been computed and added to the report for clarity and uniformity.

Airline Record, 1949 Edition. Chicago 4, Ill., Roy R. Roadcap, 1949. 160 pp., maps. $7.50.

This edition continues and expands the edition of 1948, including this year all 45 of the U.S. certificated air lines. A general survey of U.S. air-line development is added to this edition occupying the first 40 pages, and including 14 tables and 8 maps. Data on the world's 32 largest air lines, affording comparisons of route miles, weekly scheduled plane miles, revenue plane and passenger miles, and miles scheduled per route mile for 1948, are included in this section. For each U.S. certificated air line, except those that are inactive, data are given on its routes, history, equipment and facilities, managing personnel, revenue traffic statistics, income accounts, pay-load and income-account analysis, balance sheets, capitalization and financial ratios, and a historical financial survey, usually from the beginning of the company. Operating data for each company are presented for the period 1942 through 1948.

AIRPORTS AND AIRWAYS

Airport Operators Council. Papers Presented and a Selective Discussion Report Covering the Second Annual Meeting, 1949. Washington 6, D.C., 1625 K Street, N.W., Airport Operators Council, 1950. 145 pp., illus. $2.50.

In addition to the discussions and the committee reports, the following papers are included: The Stake of the Federal Government in Civil Airport Development, Delos W. Rentzel; The Airport Master Plan, J. B. Bayard, Jr.; Relation Between Airport Design and Aircraft Design, John H. Ryan; Airport Terminal Buildings, Charles Landrum; Multiple-Wheel Landing Gear Increases Runway Carrying Capacity; Commercial Aeronautical Need by Community, A. D'Arcy Harvey; Problems of Storing and Distributing Aviation Gasoline at Terminal Type Airports, R. C. Oertel; Safety Specifications for Tank Vehicles Operating on Airports, Billings Wilson; Gasoline Handling System for Greater Pittsburgh Airport, I. W. Baldwin; The FIDO Installation at Los Angeles Airport, Clarence M. Young; Bases for Establishing Rates and Charges at Terminal Type Airports, James C. Buckley; Cost Accounting Systems for Terminal Type Airports, Harley Reese; Airport Leases, Licenses and Permits, Leander I. Shelley; Development of Airport Revenues through Planning and Promotion of Consumer Concessions, Robert S. Curtiss; Development of Airport Revenues from the Sale of Food and Beverages, James K. Dobbs; Development of Airport Revenues from Automobile Parking, Kenneth E. Atkinson; Development of Airport Revenues from Corporate and Executive Aircraft, William B. Belden; Ways in Which Scheduled Air Carriers Can Assist the Development of Non-Flight Revenues at Airports, George Gardner; and What is Airfreight Facing in the 1950's?, Robert W. Prescott.

AVIATION MEDICINE

Aviation Medicine, Its Theory and Application. Kenneth G. Bergin. Baltimore, The Williams & Wilkins Co., 1949. 447 pp., illus., diagrs. $7.00.

The author's aim is to present a brief review of the physiological, medical, psychological, and epidemiological problems associated with aviation in its various aspects. Following a historical introductory chapter, the next eleven chapters deal with physiological considerations, including such topics as Atmosphere and Respiration, Speed and Acceleration, Equilibrium, Pressurization, and Noise and Vibration. The next 14 chapters, on medical considerations, include such subjects as Anoxia, Air-sickness, Fatigue, Disturbances of Vision Associated with Flying, Burns, and Flying Emergencies. Psychological subjects are discussed in the next seven chapters, including three chapters on Aircrew Neurosis, and chapters on Flying Stress, Morale, and Accidents. The final chapter deals with Epidemiology and Air Travel, and appendixes are included on I.C.A.O. Medical Requirements, Table of Average Body Build, Epidemiological Maps, International Certificates of Inoculation and Vaccination, and Yellow Fever Inoculation Centres in England. Extensive bibliographies accompany each chapter. Dr. Bergin has had extensive experience as a civil and military pilot and medical officer and at present is with the British Overseas Airways Corporation.

ELECTRONICS

The Characteristics of Electrical Discharges in Magnetic Fields, Edited by A. Guthrie and R. K. Wakerling. New York, McGraw-Hill Book Co., 1949. 376 pp., diagrs. $3.50.

The results are presented of studies carried out during the war on electric discharges in magnetic fields, particularly for the case of discharges in the vapors of uranium compounds. The most significant studies made at the Radiation Laboratory of the University of California are reported in eleven papers, about half of which were written by members of a British scientific mission working under the direction of H. S. W. Massey.

HISTORY

The National Air-Race Sketchbook, 1930 to 1949. Fred W. Buehl and Harry S. Gann. Los Angeles 6, Calif., Floyd Clymer, 1949. 84 pp., illus. $2.00.

This is the first compilation of the history of the National Air Races to be published. Races covered are the Thompson Trophy, 1930–1949, and J Division, 1946–1947; Bendix Trophy, 1931–1949, and J Division, 1946–1948; Greve Trophy, 1934–1939; Goodyear Trophy, 1947–1949; Tinnerman Trophy, 1947–1949; Sohio Trophy, 1947–1949; Allison Trophy, 1947; Kendall Trophy, 1947; and Weatherhead Service Jet Speed Dashes, 1946. Entries in each race are listed, with names of pilot and airplane, racing number, license number, engine, displacement, speed, and amount of prize money won. Three views of each winning airplane, and black-and-white sketches of other outstanding airplanes of each race, are included.

History of United States Naval Aviation. Archibald D. Turnbull and Clifford L. Lord. New Haven, Yale University Press, 1949. 345 pp., illus. $5.00.

This history, based on official sources, details the story of naval aviation, from the time of the interest shown by Assistant Secretary of the Navy Theodore Roosevelt in 1898 to the beginning of World War II. The greater part of the book is concerned with the period before 1930, concentrating equally upon planes, aviators, and administration. The parts played by appropriations from Congress, and the establishment of adequate research and training facilities, are well described. Seven chapters are devoted to World War I, and there is a separate chapter on the bombing of battleships in 1921, 1923, and 1924. The pattern of air maneuvers in connection with fleet operations, new uses for aircraft, and the findings of the various policy boards of the 1920's, including the Lampert Committee and the Morrow Board, are among other topics discussed. The final three chapters deal with the period of expansion after 1933, the approach to World War II, and a summary of the accomplishments of naval aviation in the war. Captain Turnbull is Deputy Director of Naval Records and History, and Mr. Lord was formerly head of the Naval Aviation History Unit.

Slipstream, the Autobiography of an Aircraftsman. Eugene E. Wilson. New York, Whittlesey House, McGraw-Hill Book Co., 1950. 328 pp., illus. $4.50.

Speaking from a background in naval aviation and in the aircraft industry extending over 25 years, Mr. Wilson sets down the history of the air age during the important period from 1924 to 1949. He resigned his positions with the United Aircraft Corporation and the Aircraft Industries Association in order to be free to express the views expressed here. He sees the airplane as an inherently economic vehicle, and the true basis of air power for peace as air commerce, developing under free competitive conditions without excessive regulation. Command of the air is now vital to sea power, and sea power is essential as long as air commerce cannot assume the full burden of overseas trade. Air power, as he pointed out in his earlier *Air Power for Peace*, is an integration of air force, air transport, aircraft production, and all flying which contributes to strength in the air. The goal of integration is considered by no means to have been reached, and this book is a record of this failure and the reasons for it. It should be a valuable source for reference for both the past and the future.

Hitch Your Wagon, the Story of Bernt Balchen. Clayton Knight and Robert C. Durham. Drexel Hill, Pennsylvania, Bell Publishing Co., 1950. 332 pp., illus. $3.50.

Bernt Balchen's career has been associated with flying in the north since his first solo flight with the Norwegian Navy in 1920. He was a pilot, copilot, or navigator with expeditions of Amundsen, Byrd, and others, and safely landed Byrd's *America* off the coast of France under instrument-flying conditions in 1927. He became an American citizen in 1927 while with Fokker's company but was active in Norwegian civil transport aviation during the 1930's. General Arnold took him from ferrying duties in 1941 and sent him to Greenland, and from there he went to Sweden to work with the Norwegian underground. He is now in command of an Air Force rescue command in Alaska. This biography is written with understanding and competence and contributes much to the history of American aviation. An index has unfortunately not been included.

LAWS AND REGULATIONS

Patent Tactics and Law. Roger Sherman Hoar. 3rd Edition. New York, The Ronald Press Co., 1950. 352 pp. $7.00.

This book was last revised in 1939. The present edition takes into account the rewritten and renumbered *Rules of Practice* of the Patent Office, effective March 1, 1949, changes in the handling of appeals within the Patent Office, limitations upon the Federal income tax rate on patent royalties, the new official *Manual of Patent Examining Procedure*, and other changes. The original purpose, to provide a treatise on patent tactics for the business executive, engineer, or independent inventor, remains the same. The author feels that a knowledge of tactics is essential for complete cooperation between the client and his patent lawyer.

MANAGEMENT AND FINANCE

The Foreman's Handbook, edited by Carl Heyel. 2nd Edition. New York, McGraw-Hill Book Co., 1949. 463 pp., illus., diagrs. $4.50.

This new edition contains 53 more pages than the first edition, published in 1943, including a new chapter on the basic principles of work simplification. The chapter on Government, Labor, and the Foreman has been entirely rewritten to take into account changes in labor legislation,

combustion engineering—in action—for air progress

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Gasoline—like any other combustible material—demands oxygen when it burns. So it has long seemed like a good idea to keep oxygen out of aircraft fuel tanks and thus keep gasoline a friend and not a potential enemy.

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Now, from our laboratories, comes a preliminary answer: a tiny combustion-type heater to furnish "purge gas" (oxygen-free gas) to fuel tanks—and then, of all things, to throw the heat away!

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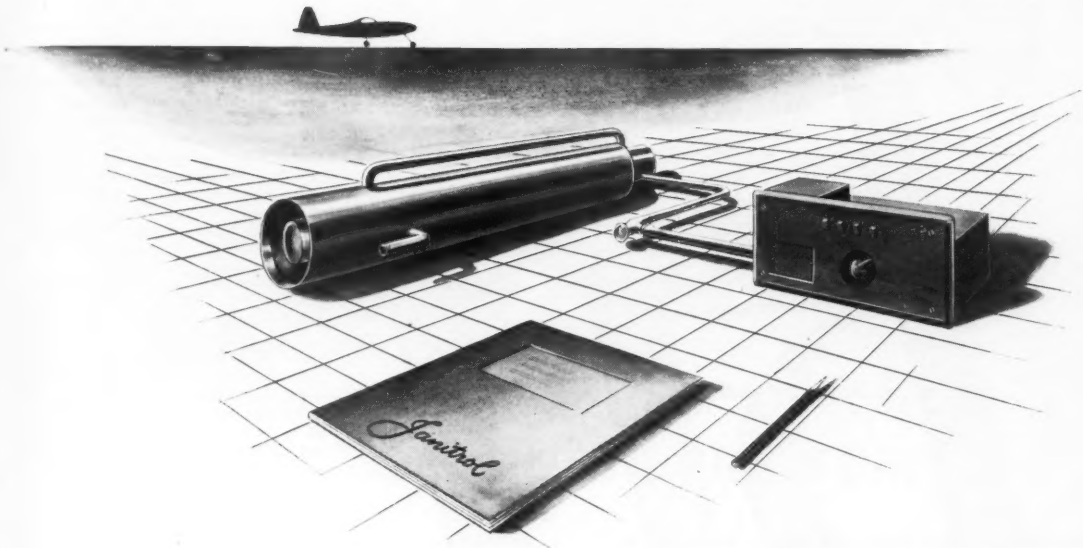

to maintain a constant fuel-air ratio at all altitudes, how to keep the "purge gas" dry and free of oxygen, how to insure safety under all conditions—and how to do all this in a "fly-weight" compact system.

Many of these problems were not new to Surface Combustion engineers—many already solved in the development of aircraft heating equipment that has served well the world over. Thus we feel sure this development will do everything expected of it, and make an important contribution to aviation progress.

If any of your problems involve combustion—whether heat is an end-product or a by-product, you'll do well to bring them to Surface Combustion.

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AIRCRAFT AND AUTOMOTIVE HEATERS *with the whirling flame*

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F. H. Scott, New York, N. Y., 225 Broadway; C. B. Anderson, Kansas City, Mo., 1438 Dierks Building; Lee Curtin, Hollywood, Calif., 7046 Hollywood Blvd.; Frank Deak, P. A. Miller, Central District Office, Engineering Development and Production, Columbus, Ohio; Headquarters, Toledo, Ohio.

and the chapter on economics has been largely recast. The authors of other chapters have revised statistical or topical parts where necessary. Written by 19 authorities, the book retains its original purpose, to present a source of constant reference by the foreman on the practical aspects of his job and the background needed to carry out its requirements.

MATERIALS

Refractories. F. H. Norton. 3rd Edition. New York, McGraw-Hill Book Co. Inc., 1949. 782 pp., illus., diagrs. $8.50.

This new edition of a book last revised in 1942 is larger by 84 pages and includes new chapters on laboratory furnaces, with particular emphasis on induction heating, new refractory materials for high-temperature use, and on refractories for use in nuclear power production and in gas turbine and jet propulsion engines. The original arrangement in sections covering the manufacture, properties, and use of refractories has been retained. Extensive bibliographies follow each chapter, and subject and author indexes are included.

Materials Engineering of Metal Products. Norman E. Woldman. New York, Reinhold Publishing Corp., 1949. 583 pp., illus., diagrs. $10.

This volume presents correlated and interpreted information on materials used in various types of industries and in various applications, as an aid to the selection of materials by engineering students, industrial designers, and practicing engineers in all fields. The first section deals with materials for light-weight construction, including aluminum and magnesium alloys, high-strength low-alloy steels, and stainless steel. Materials are next discussed for mechanical products, such as gears, springs, bearings, and threaded fasteners. Magnetic materials, electrical contacts, electrical resistance alloys, and other applications in the electrical industries are next taken up. Materials for special service, including corrosion-resistant materials and high-temperature alloys, and the testing of materials are discussed in the two final sections. Tabulated properties and characteristics of materials are included in an appendix. The author is a consulting engineer and is a faculty member at The Cooper Union School of Engineering and the graduate school at the Stevens Institute of Technology.

Cold Working of Metals. Cleveland. American Society for Metals, 1949. 364 pp., diagrs. $5.00.

Contents: Strain Hardening—Effects of Alloying Elements and Microstructure, G. V. Smith; Macro-Residual Stresses in Metals Resulting from Plastic Deformation, W. M. Baldwin, Jr.; Structure of Slip Bands and Cold-Worked Metal, R. D. Heidenreich; The Crystallographic Mechanisms of Translation, Twinning and Banding, C. S. Barrett; Deformation Textures, R. M. Brick; Recrystallization Textures, C. G. Dunn; Dislocation Theory, W. Shockley; Nucleation of Deformation, J. H. Hollomon; The Effect of Strain Histories on the Work Hardening of Metals, T. E. Tietz and J. E. Dorn; Dynamics of Slip Bands, Clarence Zener; Plastic After-Effects, J. G. Leschen; Work Hardening Under Combined Stresses, L. R. Jackson; Creep of Metals, J. D. Lubahn; Cold Work and Fatigue, Alfred M. Freudenthal; The Effect of Plastic Deformation on Solid Reactions. Part I—Diffusion Reactions, B. L. Averbach; The Effect of Plastic Deformation on Solid Reactions. Part II—The Effect of Applied Stress and Strain on the Martensite Reaction, B. L. Averbach and Morris Cohen; and The Fracture Stress of Metals as Affected by Plastic Deformation, the Stress System and Size, D. J. McAdam, Jr.

Properties of Metals in Materials Engineering. Cleveland, Ohio, American Society for Metals, 1949. 177 pp., illus. diagrs. $5.00.

This is a series of eight lectures on the properties of metals in materials engineering, presented at the National Metal Congress in 1948. Following an introduction by R. L. Templin and a review of fundamental concepts by M. Gensamer, the following papers are included: Behavior of Metals Under Direct or Nonreversed Loading, by John R. Low; Application of Fatigue Data to Machine Design, by R. E. Peterson; Determination of the State of Stress, by W. M. Murray; Analysis of Stress in Aircraft Engines, by William T. Bean, Jr.; Testing to Specific Deflections (Buckling), by E. C. Hartmann; Design for Energy Absorption, by Wendell P. Roop. Bibliographies accompany most of the papers, and an index is provided.

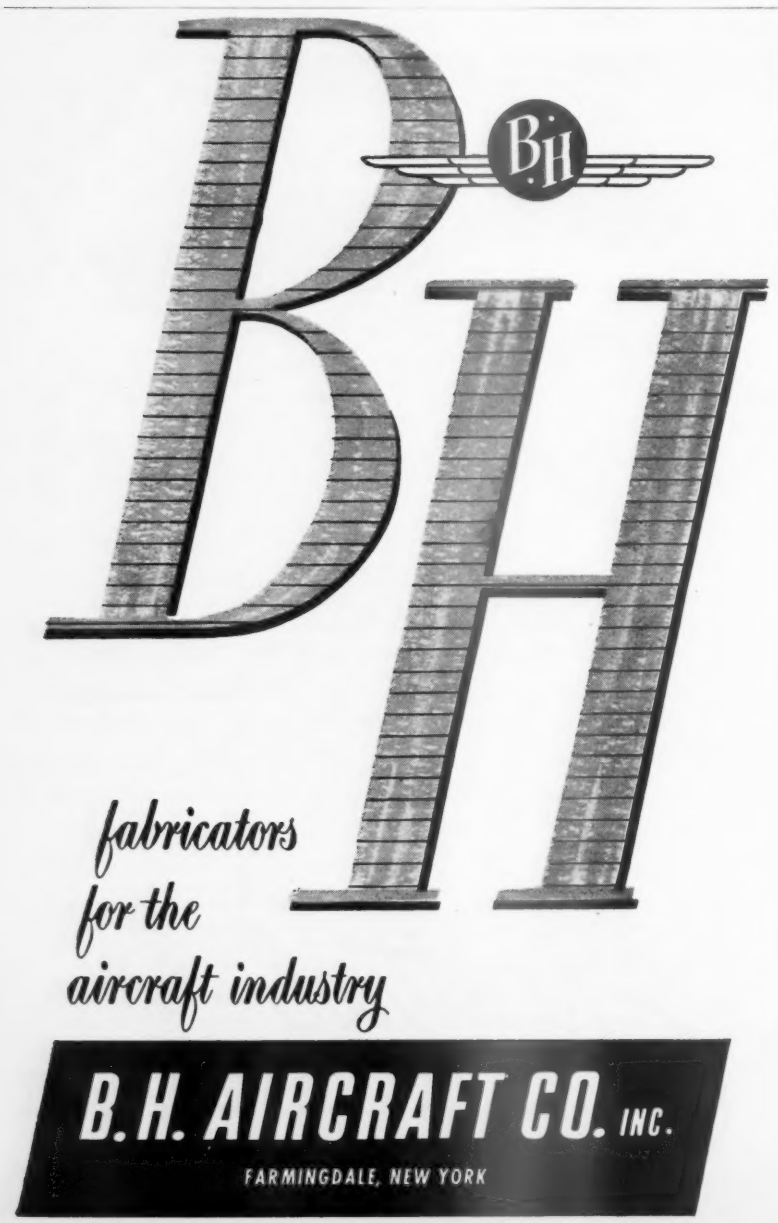
METEOROLOGY

Alexander McAdie, Scientist and Writer. Charlottesville, Va., Mary R. B. McAdie, 1949. 421 pp., illus.

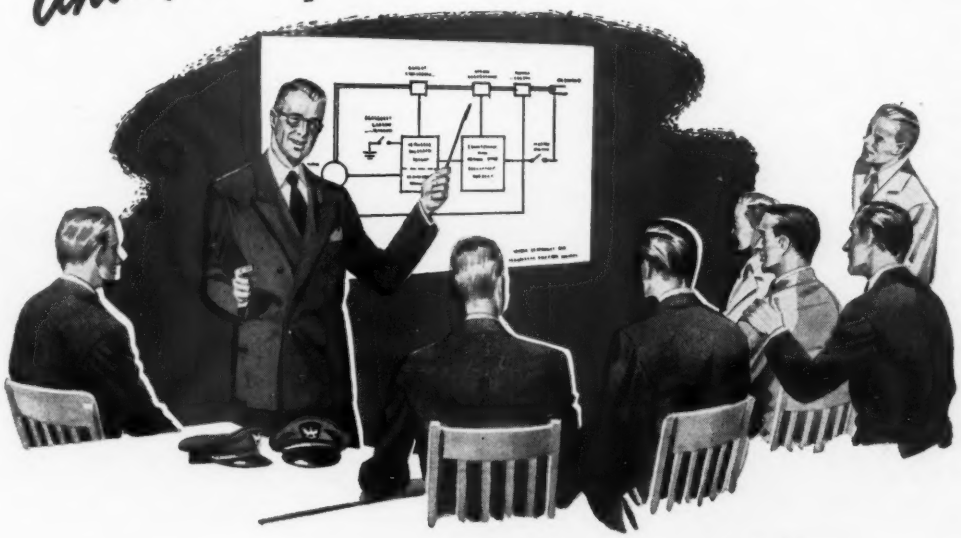
This volume contains 54 articles and essays by Dr. Alexander McAdie, who served with the Army Signal Corps and as a government meteorological official, then became director of the Blue Hill Meteorological Observatory from 1913 until his retirement in 1931. He died in 1943 at Hampton, Virginia. This volume includes some letters, a short biographical memoir, a classified list of more than 350 writings of Dr. McAdie, and a list of instruments and charts perfected by him.

Climatology. A. Austin Miller. 3rd Edition. New York, E. P. Dutton and Co., Inc., 1943. 325 pp., diagrs., maps. $5.50.

The author's aim is to provide a reasoned account of the world's climatic types for the advanced student, particularly the student of geography. Prominence is given to practical applications and the human aspect. The reader is assumed to have knowledge of the physics of meteorological processes, and this aspect is not discussed, though the implications of new meteorological outlook are taken up in a new chapter in this edition on Air Masses, and some of the introductory chapters have been rewritten to account for this. References are included at the ends of



And Now Gentlemen—



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chapters. The author is a professor of geography at the University of Reading.

Climatology. W. G. Kendrew. 3rd Edition. London and New York, Oxford University Press, 1942. 383 pp., illus. diagrs. $7.50.

This new edition of a book formerly published under the title *Climate*, and last revised in 1938, is larger by 56 pages and has been considerably rewritten, rearranged, and revised. The climatology of the surface of the earth only is treated for the most part. The first part deals with Insolation and Temperature, including chapters on the measurement of air temperature, local controls of air temperature, diurnal curves of temperatures, air masses, and the lapse rate of temperature in the upper air. Atmospheric Pressure and Winds are next discussed, including the measurement of pressure, decrease of pressure with increase of altitude and its physiological effects, movements of the air, and major regions of pressure and winds. The Vapour in the Atmosphere and Its Condensation, including rain, clouds, sunshine, and visibility are taken up next. Mountain and Plateau Climate, the Weather of the Westerlies, and the climate types such as the Sudan, the Mediterranean, and the Westerlies are discussed in the final 94 pages. A bibliography of 52 titles is included. The author is a reader in climatology at the University of Oxford.

Oscillations of the Earth's Atmosphere. M. V. Wilkes. Cambridge, Cambridge University Press, 1949. 76 pp., diagrs. $2.50.

This monograph reviews the existing knowledge of oscillations of the atmosphere. The measurement, manifestations, and causes of the lunar and solar air tides are discussed in the opening chapter, and the theory of oscillations in a rotating atmosphere is next taken up. Following a discussion of the numerical evaluation of air tides, the final chapter deals with oscillations in the atmosphere, including the outward flux of energy, the temperature variation in the atmosphere, the general treatment of oscillations, and numerical results. A discussion of results closes the book. A bibliography of 46 items is included. The author is director of the Cambridge University Mathematical Laboratory.

NAVIGATION

Electronic Navigation. Leonard M. Orman. North Hollywood, Calif., 12021 Ventura Blvd., Pan American Navigation Service; Annapolis, Md., Weems System of Navigation, 1950. 222 pp., illus. $4.50.

The purpose of this book is to present the basic features of electronic navigation systems in use, principally from the point of view of the operator. Radar and loran, the two most widely used electronic facilities, are discussed fully, and such developments as the radio altimeter, the instrument landing system, ground control approach, distance measuring equipment, omniranges, tricon, shoran, R-Theta navigation, the forthcoming course-line computer, and such British developments as Decca, consol, and gee. Considerable attention is given to the installation and maintenance of radar, and to the training of operators and available radar and loran equipment is described in an appendix. A glossary of over 450 terms, a bibliography and 101 study questions, with answers, are included. The author is director of the Army Radar Laboratory at West Point.

POWER PLANTS

Automobile and Aircraft Engines. Vol. 1. The Mechanics of Petrol and Diesel Engines. Arthur W. Judge. 4th Edition, Revised and Enlarged. New York, Pitman Publishing Corp., 1947. 307 pp., illus., diagrs. $6.00.

This is the first volume of a new two-volume edition of a book last revised in 1934. The original material has been extensively revised and rewritten, and entirely rearranged, with new chapters on Valve Cams and Followers, Vibrations in Engines, Torsional Oscillations in Engines, Engine Mountings, The Balancing of Rotating Parts, and Balancing Machines. Other chapters deal with Piston Displacement, Velocity and Acceleration, Engine Torque and Torque Diagrams, the Balancing of Engines, and considerations of flywheels, peripheral stresses, and connecting-rod stresses. The book is intended for students and engineers concerned with the design aspects of gasoline and Diesel engines.

PRODUCTION

Grinding Practice; Typical Machines and Methods Used in a Wide Variety of Work. Fred H. Colvin and Frank A. Stanley. 3rd Edition. New York, McGraw-Hill Book Co., Inc., 1950. 419 pp., illus., diagrs. $3.75.

This new edition of a standard textbook last revised in 1943 is larger by 69 pages, and much of the material has been rearranged for a more logical sequence. Information on new developments in grinding practice has been included throughout, including the new standard code for the marking of abrasive wheels, as adopted by the Standardization Committee of the Grinding Wheel Manufacturers Association.

SCIENCES, GENERAL

MATHEMATICS

Chambers' Six-Figure Mathematical Tables. Vol. I. Logarithmic Values. Vol. II. Natural Values. L. J. Comrie. London, W. & R. Chambers, Ltd.; New York, D. Van Nostrand Co., Inc., 1949. 2 vols., 576, 576 pp. $10 per vol.; $17.50 per set.

In this new revised edition of these tables, which were first published in 1844 and last revised in 1930, Dr. Comrie has greatly expanded the scope of the work to include trigonometrical tables with argument in degrees and decimals, and in radians; exponential and hyperbolic functions; inverse circular and hyperbolic functions; and tables of roots and powers. The tables have been carried to six figures instead of the previous seven, in accordance with the author's belief that 95 per cent of computational requirements are covered by six-figure tables, which can also be made linear, or nearly so, in a reasonable compass. The first volume is devoted to logarithmic values, and the second to natural values. About 24 tables are presented, and in each volume are included conversion tables, tables of physical and mathematical constants, and bibliographies of more extended tables.

Introduction to the Theory of Probability and Statistics. Niels Arley and K. Rander Buch. New York, John Wiley & Sons, 1950. 236 pp. $4.00.

This is a translation by the senior author from the third edition of a work published in Denmark in 1946, with additions and revisions. Following three elementary chapters, the discussion takes up Random Variables and Distribution Functions, Mean Value and Dispersion, Mean Value and Dispersion of Sums, Products, and Other Functions, The Normal Distribution, and Limit Theorems. The relation of the theory of probability to experience and its practical importance is next discussed, and the final three chapters deal with the application of the theory of probability to statistics, to the theory of errors, and to the theory of adjustment. A list of 43 references and various tables is included. Dr. Arley is assistant professor of physics at the University of Copenhagen, and Dr. Buch is assistant professor of mathematics at the Denmark Institute of Technology.

Measure Theory. Paul R. Halmos. New York, D. Van Nostrand Co. Inc., 1950. 304 pp. $5.90.

The author's purpose is to present a unified treatment of the measure theory which has shown itself to be most useful for its applications in modern analysis, as a text for students and a reference source for the more advanced mathematician. The first seven chapters deal with Sets and Classes, Measures and Outer Measures, Extension of Measures, Measurable Functions, Integration, General Set Functions, and Product Spaces. The final chapters cover transformations and functions, using the concept of metric space, probability, locally compact space, the Haar measure, and measure and topology in groups. The author is associate professor of mathematics at the University of Chicago.

PHYSICS

Introduction to Statistical Mechanics. G. S. Rushbrooke. London and New York, Oxford University Press, 1949. 334 pp. $5.50.

The author's purpose is to provide an introductory textbook for students especially in the field of physical chemistry and to prepare the student for the use of more detailed works. Emphasis is placed on the three basic methods of statistical mechanics, number of complexions, partition function, and grand partition function. Among the subjects discussed are the specific heat of a diatomic gas and of polyatomic gases, polar and nonpolar gases in internal fields, the law of mass action, imperfect gases, and perfect and nonperfect solutions. The relation between thermodynamics and statistical mechanics is discussed in the final chapter, and the derivation of the simple thermodynamic formulas used are given in appendixes. A bibliography of about 20 items is included. The author is a senior lecturer in theoretical physics at the University of Oxford.

Electromagnetic Theory. (Proceedings of Symposia in Applied Mathematics, Vol. II.) New York, American Mathematical Society, 1950. 91 pp. $3.00.

Seven full papers and abstracts of ten other papers are presented. The seven full papers are as follows: The New Quantum Electrodynamics, Herman Feshbach; Electromagnetism without Metric, J. L. Synge; Discontinuity in Electromagnetism, W. H. Watson; The Factorization Method and its Application to Differential Equations in Theoretical Physics, Leopold Infeld; Nonlinear Electrical Networks, R. J. Duffin; Ray Theory vs. Normal Mode Theory in Wave Propagation Problems, C. L. Pekeris; and Systems of Wiener-Hopf Integral Equations and their Application to Some Boundary Value Problems in Electromagnetic Theory, Albert E. Heins.

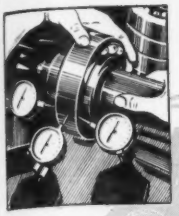
A General Kinetic Theory of Liquids. M. Born and H. S. Green. Cambridge and New York, Cambridge University Press 1949. 98 pp. $2.25.

In this volume six recent papers are reprinted from the *Proceedings* of the Royal Society, as follows: I. The Molecular Distribution Functions. II. Equilibrium Properties. III. Dynamical Properties. IV. Quantum Mechanics of Fluids. V. The Kinetic Basis of Thermodynamics. VI. Liquid HeII. Notes, additions and corrections are included in an appendix. A general outline is presented in these papers of the statistical theory of condensed matter, as a preliminary introduction.

STRUCTURES

Elementary Stress Analysis. Phillip E. Soneson. New York Pitman Publishing Corp., 1949. 351 pp., illus., diagrs. $5.00.

This textbook is designed for courses in the analysis of stresses in statically indeterminate structures. Simple frameworks in common use, including some actual structures, are the principal basis for the discussion. The beginning chapters take up Forces, Reactions, Shear and Bending Moment, and Analysis of Stresses, and Moving Loads (Influence Lines and Criteria) and Deflection of Trusses are taken up in later chapters. Among the applications are roof trusses, mill buildings, highway bridges, and railway bridges. The Duchemin method of analyzing wind loads is compared unfavorably with two other methods. The author is associate professor of architectural engineering at Purdue University.



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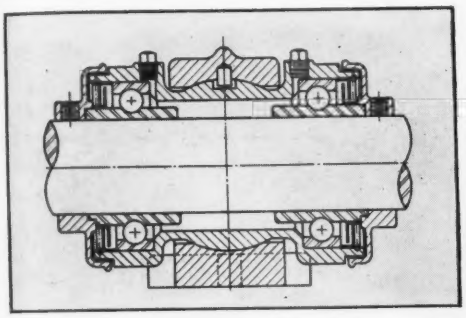

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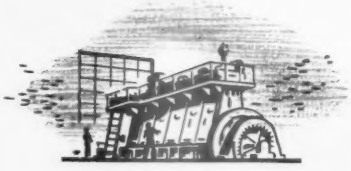

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News of Members

(*Continued from page 15*)

New home address: 431-c E. Tamarack Ave., Inglewood, Calif.

Louis G. Riache, M.I.A.S., is Consulting Engineer with Jaros, Baum & Bolles, consultants on testing facilities.

Robert L. Richmond, T.M.I.A.S., is Laboratory Technician at the Allison Division, General Motors Corporation.

John L. Senior, Jr., M.I.A.S., is President of New York Airways, Inc., which is an applicant in the New York City Area Helicopter Case before the C.A.B.

Saul Wasserman, T.M.I.A.S., is employed by the N.A.C.A. at Langley Air Force Base as an Aeronautical Engineer.

Vernon D. Westfall, A.M.I.A.S., is First Officer of Delta Airlines, Inc.

Sidney K. Wolf, M.I.A.S., Manager of Special Products Division, Federal Telephone and Radio Corporation, has been appointed Executive Director of the Munitions Board Electronic Division, which is preparing a mobilization plan to guide Army, Navy, and Air Force in dealing with the electronics industry.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Garrick, I. E., B.S., Chief, Dynamic Loads Div., Langley Aero. Lab., N.A.C.A.

Mair, William A., M.A., Dir., Fluid Motion Lab., University of Manchester.

Meyersburg, Robert B., A.B., Chief, Flight Test Section, C.A.A. (Washington, D.C.).

Transferred to Associate Fellow Grade

Crabtree, James Arnold, B.S. in Ae.E., Chief Weight Engineer, Hughes Aircraft Co.

Gartseff, Valerian N., B.S. in M.E., Head, Structures Section, U.S. Naval Air Station (Lakehurst).

Henshaw, Richard C., Mgr., Product & Sales Engineering, Lord Mfg. Co.

Pengelley, Charles Desmond, S.M. (Aero.), Head, Flutter & Vibration Section, Curtiss-Wright Corp.

Towers, John H., Vice-President, Pan American World Airways System.

Elected to MEMBER Grade

Ames, John W., B.A.Sc., Supervisor, Mechanical Test Lab., Airframe Div., A. V. Roe Canada, Ltd.

DaRosa, Edmundo A., Instructor in Charge of Aircraft, Accessory & Propeller School, Lewis College of Science & Technology.

Duee, K. R., Jr., B.S. in M.E., Aero. Sales & Service Mgr., Instrument Div., Thomas A. Edison, Inc.

Flesh, Edward M., Project Engineer, McDonnell Aircraft Corp.

Geissler, Ernst D., Dipl. Ing., Group Leader for Applied Aerodynamics & Flight Mechanics, Ord. Research & Dev. Div., War Dept. (Ft. Bliss).

Godon, W. Welsh, Designer, Power Plant Installation, Piasecki Helicopter Corp.

Hale, Robert I., B.S. in M.E. (Aero. & Indust.), Management Consultant, Booz, Allen & Hamilton.

Hopkins, Marvin A., B.S., Head, Engineering Div., Naval Aviation Ordnance Test Station.

Ilsley, John S., Sr. Design & Development Draughtsman, Messrs. Aero Controls, Ltd. (England).

Kraemer, Fritz, Dipl. Ing., Research Engineer, Ord. Research & Dev. Div., Sub-O-Rkt (Ft. Bliss), Dept. of the Army.

Leedeen, Edward A., Chief, Programs Adjustment Branch, Aircraft Scheduling Unit, Air Materiel Command, Wright-Patterson Air Force Base.

Mac Callum, Alan M., Electrical Project Engineer, Eclipse-Pioneer Div., Bendix Aviation Corp.

Nordyke, Sam E., Aero. Engineer (Civilian), U.S.A.F.

Norman, Carl C., B.S.Ae.E., Instructor in Math., Mechanics, Structures, The Aeronautical University, Inc.

Otte, Emerson, Lt. Comdr., U.S.N.; Maintenance & Material Officer, Naval Air Station (Glenview).

Ringleb, Friedrich O., Dr. Rer. Nat. Habil., Research & Development Specialist, Naval Aircraft Factory (Philadelphia).

Rubert, Kennedy F., Ph.D., Aero. Research Scientist & Head, Internal Aerodynamics Section, N.A.C.A., Langley Air Force Base.

Schult, Wilhelm F., Independent Airplane Designer, Self-Employed.

Sly, Edward D., Lab. Research Analyst "A," Ryan Aeronautical Co.

Strohm, Paul R., B.S., Assistant to Resident Engineering Representative (West Coast), T.W.A., Inc.

Uhl, Edward G., B.S., Engineering Physics, Chief Project Engineer, The Glenn L. Martin Co.

Wunch, William Stuart, M.S.E. (Aero.), Aerodynamicist, Electronics Dept., Hughes Aircraft Co.

Transferred to MEMBER Grade

Alford, William L., B.S. in Ae.E., Aero. Research Pilot, Flight Research Div., N.A.C.A., Langley Air Force Base.

Dilworth, John A., III, Ae.E., Research Physicist, United Gas Pipeline Co.

Harper, John Alden, B.S. & E. in Ae.E., Engineering Test Pilot, N.A.C.A., Langley Air Force Base.

Hughes, Charles S., M.S.E. (Aero.), Assistant Prof. of Aero. Engineering, University of Tulsa.

Jablecki, Leon S., M.S.M.E., Major, Chief, Aircraft Structures Test Unit, Wright-Patterson Air Force Base, U.S.A.F.

Peterson, Benjamin G., B.S., Project Flight Test Aerodynamicist, North American Aviation, Inc.

White, Eugene H., Special Projects Engineer, Saval, Inc.

Elected to Associate Member Grade

Brown, T. Wistar, A.B., Secretary, Sales Mgr., Eckert-Mauchly Computer Corp.

Gruberg, Victor L., Ph.D., Managing Editor, Airindex, Ltd. (England).

Saxe, Robert K., Departmental Leading Chief, Aviation Technical Training Dept., Naval Air Station (Glenview).

Stone, Grant B., A.B., Mgr., New York Office, Solar Aircraft Co.

Vought, John H., Handbook Supervisor, Engineering Div., Solar Aircraft Co.

Elected to Technical Member Grade

Balasubramanian, M. S., B.Sc., Ground Engineer & Inspector in Maintenance Dept., Air India International, Ltd.

Griffith, James A., Airplane Analyst, North American Aviation, Inc.

Helms, J. Lynn, 1st Lt., U.S.M.C.; Aviation Engineering Officer, Jet Training Unit One, N.A.A.S.

Jacobson, Herbert B., Instrumentation Design Engineer, Engineering Flight Test, North American Aviation, Inc.

Poole, Harmon A., Jr., S.B., Jr. Engineer, Analysis Group, Eclipse-Pioneer Div., Bendix Aviation Corp.

Transferred to Technical Member Grade

Ahlstrand, Maurice C., Aircraft & Aircraft Engine Mechanic, Northwest Airlines, Inc.

Alexander, James F., Jr., B.A.E., Draftsman-Designer, Jacobs Instrument Co.

Barker, Lloyd W., B.S. in Ae.E., Design Engineer, Aircraft Div., Globe Corp.

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Seattle 22, Washington

Boothroyd, Joseph A., Jr., B.S. in Ae.E., Project Engineer, Aviation Gas Turbine Div., Westinghouse Electric Corp.

Bosserman, Henry C., B.S., Jr. Engineer "B," Boeing Airplane Co. (Seattle).

Burke, Harry E., B.S.

Bushong, William D., B.S.

Calehuff, Girard L., B.S. in Ae.E., Researcher & Designer, The Pennsylvania State College.

Clinton, Phillip M., A.A. in A.E.

Cooley, James L., B.S., Analytical Engineer, Research Dept., United Aircraft Corp.

Costa, Manuel P., B.S.Ae.E., Maintenance Engineer, Auto City Plating Co.

Coyle, James J., M.S. in Ae.E., Lt. Comdr. & Naval Aviator, U.S.N.

Crim, Almer D., B.S.Ae.E., Aero. Engineer, N.A.C.A., Langley Air Force Base.

Danberg, James E., B. of Ae.E., Student, The Catholic University of America.

Deep, Raymond A., B.S. in Ae.E., Graduate Student, University of Alabama.

Domich, Eugene G.

Doyle, Ervin F., B.S.Ae.E.

Dreisbach, John F., B.Ae.E.

Dunn, Thomas J., B.S.M.E., Engineer Trainee, Chance Vought Aircraft Div., United Aircraft Corp.

Elliott, John L., B. of Ae.E., Stress Analyst, North American Aviation, Inc.

Faucett, Richard S., A.A. in Ae.E., Engineering Assistant, Ordnance Aerophysics Lab., Consolidated Vultee Aircraft Corp.

Gohl, James R., B.S.E. (Aero.), Graduate Student, University of Michigan.

Gorjance, William J., B.Ae.E.

Grafton, William L., B.S. in Ae.E., Aero. Engineer, N.A.C.A., Langley Air Force Base.

Gudmestad, Gordon K., B.Ae.E., Jr. Engineer, Stress Analysis, Boeing Airplane Co. (Seattle).

Hallen, Byron W., Aviation Cadet, U.S.N.

Hauser, Howard M., B.S.

Hobbs, John W., B. of Ae.E.

Holdridge, Robert D., Ae.E.

Hudson, William H., B.S. in M.E., Research Analyst, North American Aviation, Inc.

Hutchinson, Charles H., B.Ae.E., Graduate Student, University of Minnesota.

Janick, Theodore S., B.S.Ae.E.

Kautt, Ervin T., B.Ae.E., Stress Analyst "C," North American Aviation, Inc.

Knemeyer, Franklin H., M.S. in Ae.E., Aero. Engineer, U.S. Naval Ordnance Test Station (Inyokern).

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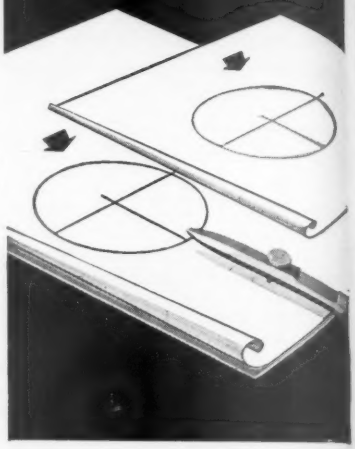

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Seventh Annual Personal Aircraft Meeting—Hotel Lassen, Wichita—May 19–20

Annual Summer Meeting—Western Headquarters Building, Los Angeles, July 12–14

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to
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WANTED

Engineers—The U.S. Naval Ordnance Experimental Unit has recently been established and is located at the National Bureau of Standards, Washington, D.C. The following vacancies exist in grades GS14, $8,800; GS13, $7,600; and GS12, $6,400; Aeronautical Engineers, Mechanical Engineers, Electronics Engineers. Assignments will include consultation, testing, evaluation, and product engineering in the development of guided missiles and components. Applicants must have had experience, preferably in connection with guided missiles or pilotless aircraft, in one or more of the following fields: Aerodynamics, Propulsion, Structures and Design, Control Mechanisms, Electronics, Production and Manufacture, Requirements and Specifications, and Flight Testing. Project engineer and staff positions are open. Enclose completed copy of Civil Service Application Form 57 (obtainable at local post office) and address inquiries to Officer in Charge, U.S. Naval Ordnance Experimental Unit, National Bureau of Standards, Washington, D.C.

Engineers—Aircraft Instrument—Exceptional opportunity for highly qualified engineers at staff level. A wide range of positions now open in product development and production design. Projects require electronics, electromechanical, and mechanical background. **Application Engineers**—Graduate engineers with extensive design experience in air-frame and/or aircraft accessory field. Work involves application and installation design of aircraft instruments in military aircraft. Knowledge of modern fuel systems desirable. **Electronics Engineers**—Preferably with degree, or equivalent experience, in both aeronautical and electrical engineering. Please send professional résumés to: Leo A. Weiss, President, Aviation Engineering Corporation, 103-30 99th St., Ozone Park 16, N.Y.

Structural Designers—With extensive stress analysis and testing background and **Structures Engineers** with a minimum of 4 years' stress analysis experience required for advanced problems in load criteria, design, and analysis. Inquiry should include comprehensive experience résumé. Address: Manager, Engineering Personnel, Bell Aircraft Corporation, P.O. Box One, Buffalo 5, N.Y.

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Physicist—For design and development of electronic and mechanical instrumentation equipment used in the pursuit of flight-research work. Several years of theoretical and practical experience necessary. Salary commensurate with qualifications. Permanent position. Give details in first letter. Cornell Aeronautical Laboratory, Inc., 4455 Genesee Street, Buffalo 21, N.Y.

142. Sales Executive—Must have extensive sales management experience to direct and coordinate existing sales departments, each dealing in specialized technical fields in administration of Government contracts, sale of specially engineered products to aircraft manufacturers, also selling controls for industrial use, radio in personal airplanes, and sound equipment in specialized consumer fields. Must be experienced in guiding and directing advertising programs and analyzing potential markets and operating records. Technical background desirable but not essential. Good business judgment and operating and planning experience required. Our employees know of this advertisement. Location, Mid-West.

AVAILABLE

149. Aeronautical Engineer—B.S.Ae.E. Approximately 5 years' engineering experience. One and one-half years in aerodynamic development of advanced aircraft. Last 2½ years as subsonic and transonic wind-tunnel test engineer. Ability in technical writing and graphic design studies. Some mechanism design experience. Has had business training. Desires position of responsibility in development of aircraft and component design or in research, air line or industry. Age, 29.

148. Aeronautical Engineer—Bachelor of Aeronautical Engineering degree, North Carolina State College, 1943. Fifteen months of detail drafting and design, with 6 months on wind-tunnel test models for leading Navy fighter manufacturer. Three and one-half years' experience in U.S. Marine Corps as airplane and engine mechanic with carrier and land-based fighter squadrons. Prefers position on East Coast. Age, 29.

147. Aeronautical Engineer—B.S. in M.E. and Aero Option, graduate credits. Two years' experience in flight research with reciprocating, turbojet, and rocket-powered aircraft. Four years' experience with rocket propulsion systems, theoretical analysis, design, shop practice, testing, development, and reports. Extensive administrative work throughout. Successful liaison work with the Services and vendors. Desires part-time position Long Island or Connecticut requiring broad application of past experience. Age, 28.

146. Aeronautical Engineer—Structures—Graduate M.I.T., 1938, B.S. Ten years in Aeronautical Structures. Specialized in electric strain-gage analysis and recording. Familiar with air-frame production methods, sheet-metal forming, and plasticity of light alloys. Commercial pilot with multieagined and instrument ratings. Desires structures flight-testing position.

145. Engineer—B. of M.E., 1949. Prior to college had served as toolmaker's apprentice; tool design experience with West Coast aircraft manufacturer. Desires location in Mid-West or East with propulsion or equipment manufacturing company.

144. Engineer—Desires position in East. June, 1949, graduate, B. of M.E., Aeronautical option. Interested in propulsion work; has had special courses in related subjects, compressibilities; has had some drafting experience.

143. Mechanical Engineer—Licensed Professional Engineer. Ten years' experience; 2 years' teaching evening classes, Washington University, St. Louis, Mo. Supervisory experience includes 3 years as Chief of Airframe, 1 year as Project Engineer (Power Plant), 1 year as Group Engineer (Power Plant), 1 year as Lead Man (Power Plant and Preliminary Design). Active Wright Field and BuAer contacts 1943–1945; active C.A.A. Washington contacts 1945–1946. Experienced in preliminary design (7 years), including practical estimations of man power (shop and engineering) and material costs. Diversified experience ranges from complete airplane and guided-missile design to components, including liquid oxygen test devices, injector plates, rocket motor shells, high-speed bearing applications, miniature power plants, and optics systems for seekers. Prefers responsible job with a small aggressive and well-financed group. Currently holds two Professional, and six Civil Service ratings.

141. Aviation Executive — Captain, Naval Aviator, retired in 1947; excellent health. Twenty years' experience, covering organization, administration, operation, manufacturing, and sales of military and transport aircraft; air transport operating experience. Excellent contacts in Government and aviation and air transport industry. Familiar with Navy and Air Force procurement procedures; outstanding record. Past 10 years active in Washington area. Will consider Washington representation, connection East Coast aviation, or allied activity. Familiar with Europe and will consider assignment in that area.

140. Physicist—Summer position. B. Aero. E., 1943, from New York University. Presently studying physics at Columbia University. Three and one-half years' experience in aeronautical weight engineering.

139. Aeronautical Engineer—B. Aero. E., 1948. One and one-half years' experience in stress analysis. Age 25; single; location open.

138. Aeronautical Engineer—B.S.Ae.E., Lawrence Institute of Technology, June, 1949. Two years' experience in design and construction of experimental racer; also experience with glider structures and wind-tunnel operation. Three years in Air Force as engine mechanic and flight engineer. Experienced in machine operation and machine-shop practices. Desires position as aeronautical design and development engineer, research engineer, or instructor for aeronautical subjects. Location open. Age, 27.

137. Aerodynamicist — Mathematician — M.Aero.E. Five years with leading manufacturers. Original work in wing theory. Capable group leader. Age, 27; married. Will relocate if necessary. Will consider research or teaching.

136. Research and Development Engineer—Structures and Aerodynamics—Sc.D. Twelve years' experience of responsible capacity in design, research, and development of aircraft components. Has spare time to consider outside assignments for research, development, design, and/or technical studies of aircraft components. Time dedicated to these projects would ensure prompt service.

135. Associate Professor of Aeronautical Engineering—Design and Structures Engineer—Available for employment in teaching or in industry. Scholastic record includes B.S. degree and M.S. degree from Harvard Graduate School of Engineering, with work in aeronautics and applied mechanics. Early teaching experience as graduate assistant and as part-time instructor while employed in industry. Present associate

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134. Wind-Tunnel Consultant—Graduate engineer with 9 years' experience in wind-tunnel testing and design, including 3 years in supersonics. Has designed and placed into successful operation three complete supersonic wind-tunnel testing facilities. Desires to design supersonic wind tunnels, including controls, power plants, air drying equipment, pressure and force measuring equipment, and optical instruments for commission.

133. Aeronautical Engineer—Engineering Test Pilot—Registered Professional Aeronautical Engineer. Two degrees, University of Arizona. Graduate work at Cal. Tech., U.C.L.A., and U.S.C. Licensed commercial pilot with helicopter rating. Fifteen years' experience about evenly divided between design, analysis, and testing work on large aircraft; rotating wing aircraft; and teaching. Employed in administrative capacities last 5 years. Age, 37; married; location open. Further data on request. Can travel anywhere, on reasonable notice, for personal interview.

132. Management or Administration—Age, 30; single; A.B. degree, University of Pennsylvania. Major in political administration, courses applicable to business administration. Courses in industrial engineering including industrial relations, business and Government, organization and organizational structure. Aeronautical engineering courses in elementary aerodynamics, performance calculation, aircraft drafting, and engineering. Almost 6 years in aircraft testing in last position. Desires permanent position on junior level in management or administration with opportunity for advancement. Philadelphia, Pa.

131. Industrial Relations Director—Experienced in the practical solution of problems encountered in increasing production and employer-employee understanding through adequate training programs, employee services, and correct public relations. Extensive background covers over 15 years' aeronautical experience in increasingly authoritative and responsible positions, including Instructor, Teacher, Training Superintendent, and Industrial Relations Director. Background includes mechanics (A & E) on-the-job and apprenticeship instruction, vocational education and guidance, conference leadership, preparation and use of teaching aids and demonstration devices, beneficial suggestion and patent systems, work simplification, employment, welfare and recreation activities, cafeteria management, retirement, and insurance. Age, 34; married. Desires position in administrative field with air line, industry, or allied field.

130. Aeronautical Engineer—Design, stress, or research. Doctor's Degree. Ten years' industrial experience in responsible design and research capacity. Presently, head of aeronautical option with eastern college. Would consider with interest an outside position for a design, research, and/or development assignment in structures or general air-frame design field. Could dedicate up to 200 engineering man-hours per week by utilizing other faculty members with equivalent industrial experience.

129. Associate Professor—Aeronautical or Mechanical Department. Doctor's Degree. Ten years' industrial experience in supervisory design capacity. Teaching experience in stress analysis, aircraft structures, theory of machines, thermodynamics, fluid mechanics, etc. Wants simi-

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ar position with university in New York Metropolitan Area or vicinity.

128. Aeronautical Engineer—B.S., M.S. in Ae.E. (R.P.I.). Three years' experience in aircraft field, including design and installation of rocket motors and high-pressure components for missiles; assistant project engineer on high-pressure gas booster, covering contract negotiations, preliminary design, liaison work, testing. Two years' experience in home construction and contracting, involving varied business negotiations; business contacts. Familiar with legal and administrative operation of engineering firm. Six months as instructor at R.P.I. Age, 26; married.

126. Aeronautical—Mechanical Engineer—B.S. Aero. Engrg., University of Michigan. Age, 29. One year's experience in aircraft production, design, and stress analysis. Three years' experience in operation and maintenance of Naval aircraft. Four years as project engineer of plant expansion program entailing equipment design, layout, purchasing, installation, and operational follow-up. Holds private pilot's license. Registered Professional Engineer, Commonwealth of Massachusetts. Will complete requirements for B.B.A. in Management, June, 1950. Desires position in planning or development group.

125. Company Representative—Aeronautical Engineer—Test Pilot—B.S. in Ae.E., M.I.T. (1940); also holds A.B. degree; current post-graduate work in aeronautical engineering. Graduate of Navy Test Pilot Training School with 1½ years' experience as a project test pilot in the Flight Test Division, N.A.T.C., Patuxent River, Md. Fifteen years' total pilot experience in 79 types of aircraft; 9 years as Naval Aviator; 3,800 hours pilot time. Qualified single- and multiengined land- and seaplanes, jets, and helicopters. Two and one-half years' civilian aeronautical engineering experience in manufacturing, overhauling, and repairing; 3 years' military aircraft maintenance. Familiar with military aircraft specifications and design requirements. Age, 32; desires position utilizing combined aeronautical experience in which personal military contacts would be of value, such as company sales representative. Flight-test or engineering position acceptable as a start. Available for interview; location open.

124. Aeronautical Engineer—B.S. Aeronautical Engineering, M.I.T.; Age, 23; single. One year's experience as Liaison Engineer. Three months as draftsman. Interested primarily in stress analysis. Location open.

123. Aeronautical Engineer—B.S. in M.E. (Aero.), June, 1949, Carnegie Institute of Technology. Working as design engineer since graduation. Four years in U.S.A.A.F. as B-26 9th A.F. pilot. Completed 9 months' course as aircraft maintenance officer (partly jet engines). Desires position in aircraft engine industry, preferably jet or rocket. Location open. Age, 28; married.

122. Aerodynamicist—Many years' research experience with leading Government organization. Six years with two large aircraft manufacturers. Extensive knowledge of wing characteristics. Considerable experience with wind-tunnel testing and general knowledge of aerodynamics. Married; West Coast preferred.

121. Engineer—Pilot—B.S.M.E. (Aeronautical). Three years engineering design; 4 years naval aviator; 3 years' flight-test engineering; 3,000 hours single- and multiengined; C.A.A. commercial and instrument rating. Prefers pilot position, test, production, or other executive work.

120. Aeronautical Engineer—Graduate of the Academy of Aeronautics course, "Design and Construction." Holds C.A.A.-A. & E. license issued in 1943. Experienced in sheet-metal structures with leading air carrier. Flight engineer with cold Weather Test Detachment in Alaska, service-testing B-17 airplane. Experienced in high-frequency radio control of model aircraft. Desires position in research or testing. Age, 26; married. Location open.

119. Aeronautical Engineer—Extensive experience in flight research, wind-tunnel testing, and design, specializing in applied aerodynamics and stability and control. Capable project leader or will work alone. Age, 32. Must locate in California or the Southwest.

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101	Introduction to Shock Wave Theory—J. G. Coffin, Kaiser Fleetwings, Inc. 106 pages; 33 work tables & charts. (July, 1947, p. 28.)† (Ozalid.)	$3.50*
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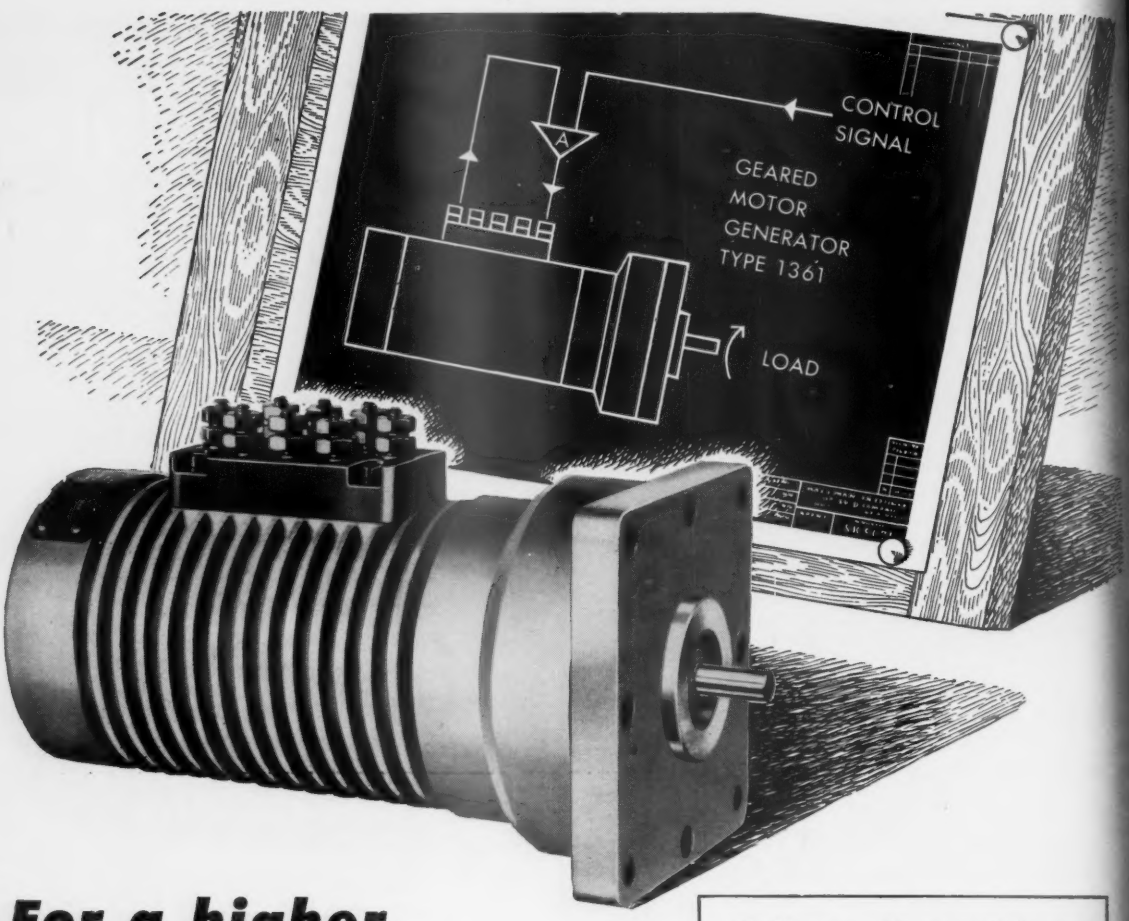

For a higher order of PRECISION *in control*

The characteristics of Kollsman miniature Motor-Driven Induction Generators suggest many remote indication and control applications. These light, space-saving units—precision-engineered for extreme sensitivity—combine motors of high torque/inertia ratio with generators offering *linear voltage vs. speed* ratios over a wide range.

These Motor-Driven Induction Generators are representative of a complete line of small Kollsman special-purpose AC motors. If those available do not meet the requirements of your particular instrumentation or control problem, Kollsman laboratories are staffed and equipped to develop a unit to your specifications. For further information, write: Kollsman Instrument Division, Square D Company, 80-68 45th Avenue, Elmhurst, N. Y.

Kollsman Motor-Driven Induction Generators

Motor characteristics: Maximum torque at stall—smooth-running (will not "cog"), fast-reversing—operate from 2-phase source, or from single-phase source with phase-shifting condenser.

Generator characteristics: Low residual voltage—output/residual voltage ratio of 100:1 in some models—residual voltage "spread" as low as 2 millivolts—available with built-in voltage temperature compensating network—constant frequency output—amplitude directly proportional to speed.

Unit characteristics: Both rotors mounted on same shaft, assuring positive alignment—geared models, with ratios between 5:1 and 75,000:1, designed to safely transmit a maximum torque of 25 oz./in.—backlash held to a minimum.

KOLLSMAN INSTRUMENT DIVISION

SQUARE D COMPANY

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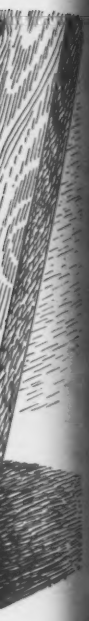

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